

CALENDAR LOG 2024



Catalog 24

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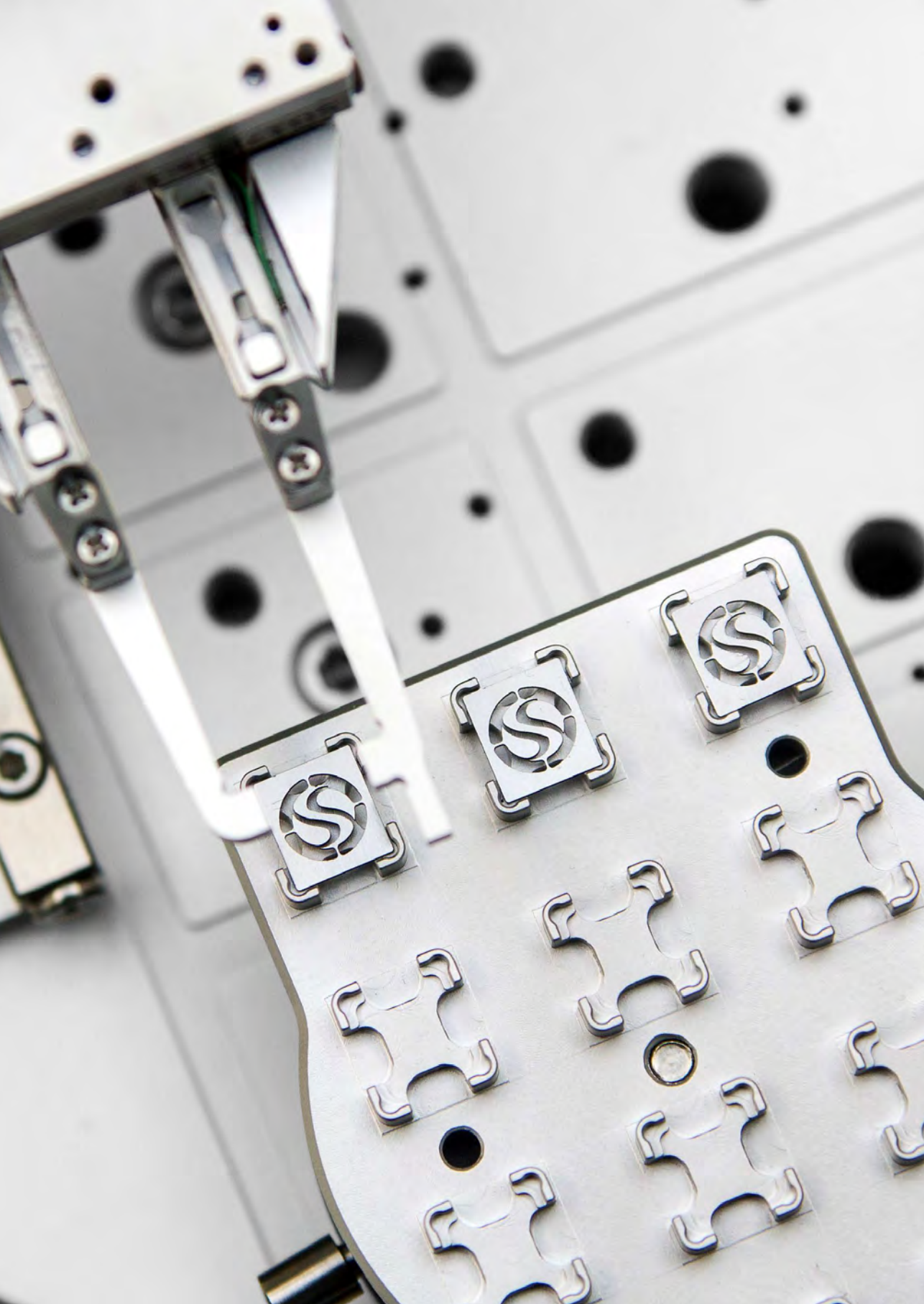
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The information given in this catalog has been carefully checked. Nevertheless, errors cannot be completely excluded. To always receive the latest information and specifications on our products, please contact our team or visit smaract.com.

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Dear customer,

Are you looking for innovative products to advance your applications in the field of high precision technology? Whether it's positioning technology, metrology or automation technology, we are the right partner for you.

Your confidence in our capabilities and joint successes have led our team to grow to 220 highly skilled members.

Our ever-growing product portfolio includes proven items and/or systems for your diverse needs. In addition, we excel in designing special devices tailored to your needs and implementing them in an uncomplicated and speedy manner. We have strengthened these capabilities by establishing three business units.

In our **Motion** business unit, we develop and produce high-precision, compact products for nano-positioning that meet the highest demands while being easy to handle. Our product classes are:

- **SMARSLIDE** – piezoelectric positioning stages with a large positioning range from a few mm to over a meter, which can also be used under extreme environmental conditions
- **SMARSHIFT** – fast and highly accurate electromagnetic positioning stages
- **SMARFLEX** – high resolution and dynamic scanners based on compliant structures
- **SMARBOTIC** – complex positioning systems and robots with multiple degrees of freedom

Our **Metrology** business unit offers components and solutions for high-resolution measurement of position displacements as well as tools for component characterization and failure analysis. Our measurement systems are:

- **PICOSCALE Interferometers** – compact laser interferometers with a picometer resolution
- **METIRIO®** – miniaturized optical encoders; also for demanding environmental conditions

Our solutions for component characterization are:

- **PICOSCALE Vibrometers** for the detection of in-plane and out-of-plane vibrations with pm resolution
- **SMARPROBE** – nano-probing platform that allows to push the limits of technical feasibility in failure analysis on wafers, ASICS and MEMS.

In our **Automation** business unit, we support you in all aspects of automating the production of miniaturized components and systems, such as optical and opto-electrical assemblies. We design and produce high-throuput production equipment, including development of the production process, if required. The installation and commissioning of our systems at your site and the usual SmarAct service are of course included.

This catalog only gives you an insight into our product portfolio. Please feel free to ask for details and get in touch with our contact persons, so that together we can ensure that you benefit from our services in the best possible way. We look forward to your next challenges!

With kind regards,



Michael Weigel-Jech
CEO SmarAct Automation



Axel Kortschack
CEO SmarAct



Sebastian Rode
CEO SmarAct Metrology



HIGH QUALITY 
MADE IN GERMANY

Your Partner for High Precision in Positioning, Automation and Metrology

Customer Service

To meet your specific requirements – no matter whether it is a highly complex or a recurrent high-volume OEM positioning system – is our main interest. We will support you with maximum flexibility in developing and manufacturing custom solutions. Our team consists of experts with technical backgrounds in fields such as physics, materials science, optics and life science.

Professional Support

As part of a fully customer oriented company, we will help and support you during the installation and setup of your new positioning solution. The team also offers immediate and comprehensive technical support to keep up your applications operating time.

Customization and Engineering Service

Do you have a new challenging task in the field of positioning, automation or metrology and the products and solutions presented in this catalog do not quite meet your specific criteria? We are eager to hear about your project and design the perfect solution for it. Please get in contact with us.

Equipment Rental Service

Many of our positioning and metrology systems can be rented. We would be very happy to support you regarding rental terms, conditions and product availability.

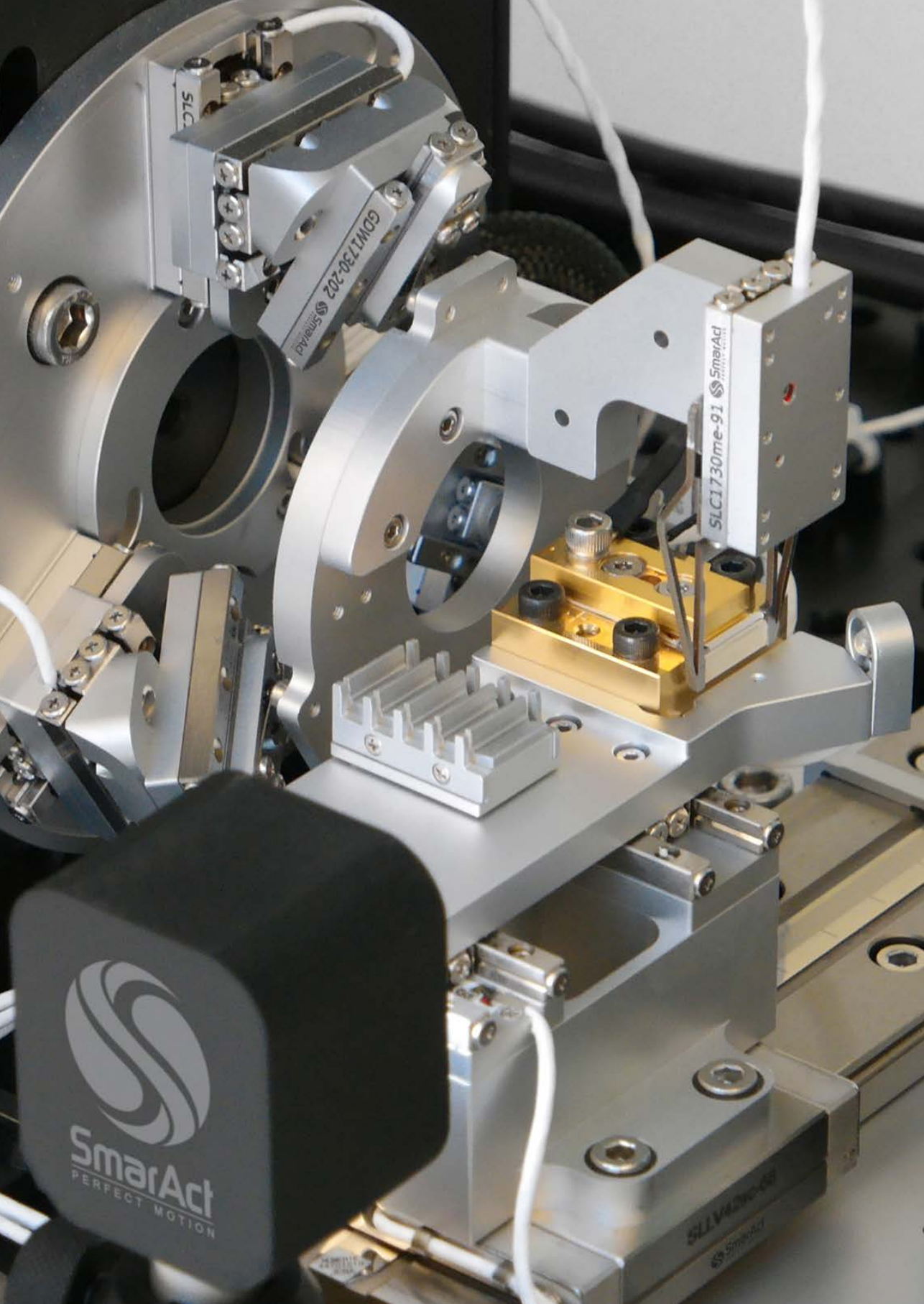
Laboratory Services

Performing measurements, investigating components in general or conducting feasibility studies for you is a service we are happy to offer. Please do not hesitate to contact us to discuss feasibility, conditions and availability.

Commitment to Quality

SmarAct is certified according to the ISO standard 9001:2015 and always driven to deliver the best solutions and products for laboratory and industry applications.





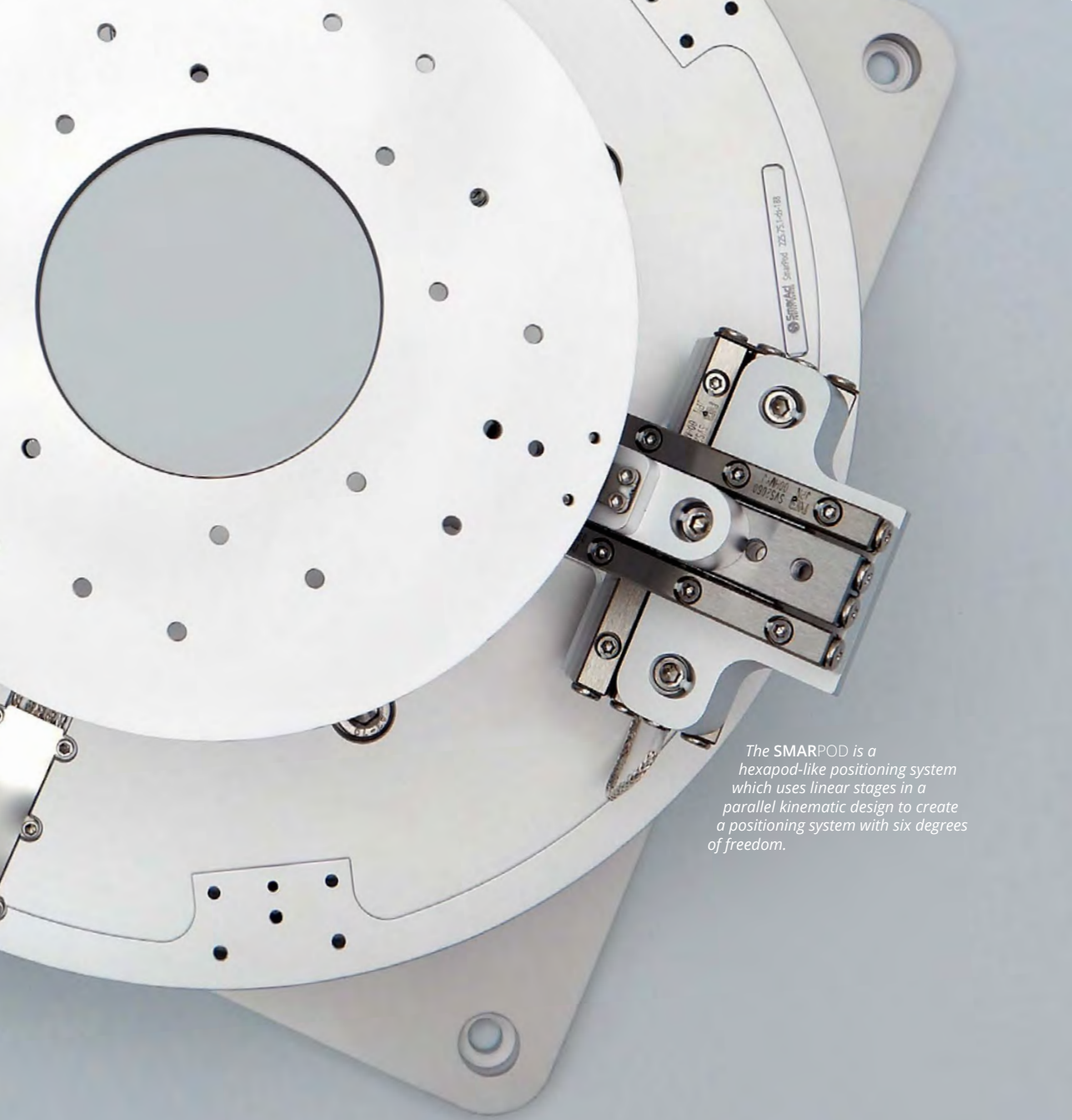
SLC

GDWT1730-202
SmarAct

SLC1730me-91
SmarAct


SmarAct
PERFECT MOTION

SLC1730me-91
SmarAct



The SMARPOD is a hexapod-like positioning system which uses linear stages in a parallel kinematic design to create a positioning system with six degrees of freedom.

 **SmarAct** | motion

Miniaturization in all fields of application increases the demand and requirements for compact and high-resolution positioning solutions.

SmarAct Motion develops and uses various technologies with specific advantages that you can discover on the following pages. We have developed this for you to meet the diverse requirements for high-precision positioning in different application areas.

All fields of application have one thing in common: the need for very high accuracy and flexibility. A large range of standard components consisting of linear, rotation and goniometer stages is supplemented by micro-grippers for handling small components like lenses or probes. Our versatile control systems and comprehensive software development kits enable easy and efficient integration into your own control environment. For better identification the drive technologies are annotated with the following icons throughout this catalog and on SmarAct products:



Stick-Slip Piezo Driver



Scanner Piezo Driver

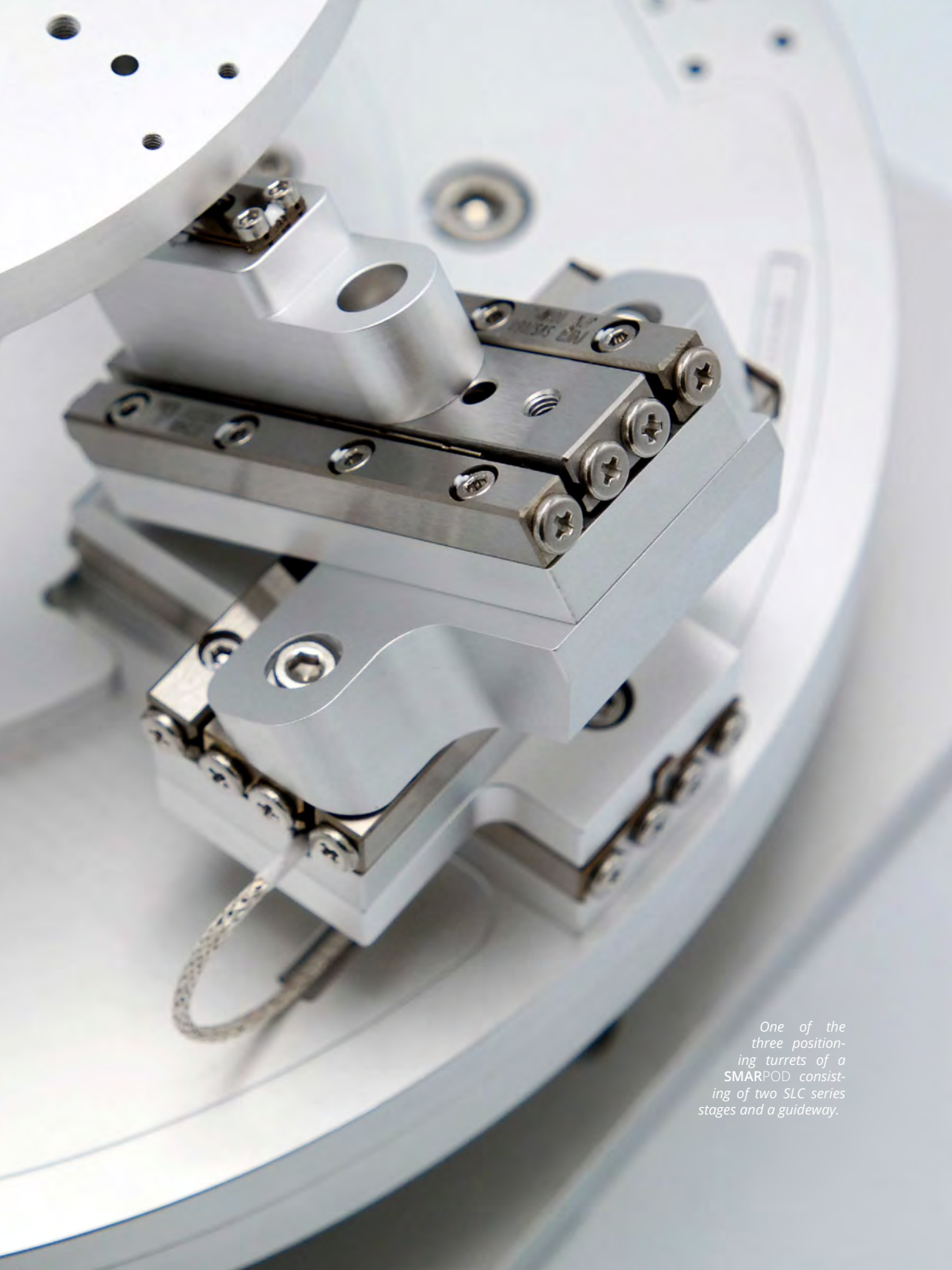


Electromagnetic Driver

Our high-precision positioning systems and compact robots make amazing things possible.

You are welcome to talk to our specialists about your specific requirements. If our standard product range does not fit your required specifications, we will be happy to offer you customized versions of our products as well as the development of complete solutions according to your demands. This includes mechanical and electrical components, as well as software.


We invite you to be inspired by the variety and high modularity of our motion technologies and positioning solutions shown on the following pages.



One of the three positioning turrets of a SMARPOD consisting of two SLC series stages and a guideway.

SMARSLIDE

High Precision Piezo Stages

 **SMARSLIDE** stages use SmarAct's stick-slip piezo drive technology, which is unique in combining the unmatched resolution of the piezo motion principle with macroscopic travel ranges made possible by repeated stepping. The stages feature large positioning ranges from a few mm to over a meter for linear stages and of several degrees for rotation and goniometer stages. The **SMARSLIDE** positioners provide you with a number of advantages for your nanopositioning systems:

High Resolution and Long Travel Range

SMARSLIDE piezo stages provide closed-loop positioning resolution of below one nanometer with high positioning repeatability even over long travel ranges.

Compact and Versatile

Most stage designs work independent of their mounting orientation. Even very complex and space constrained requirements can be met. For example, the **SMARSLIDE** SLC-1720 linear stage with a size of 22 x 17 x 8.5 mm is the world's smallest closed-loop piezo stage with nanometer resolution and macroscopic travel range.

Self-Clamping and Backlash-Free

Since the movable parts of the stages are permanently coupled to the piezo drives via friction elements, **SMARSLIDE** piezo stages are backlash-free by design and keep their position even if the control electronics are switched off. Moving the slide by hand does not harm the stage or piezo drive.

Low Thermal Drift and High Resonance Frequencies

A high degree of miniaturization combined with perfect material selection and optimized control modes ensure low thermal drift and high resonance frequencies.

Vacuum Compatibility

Nearly all **SMARSLIDE** stages and positioning systems are available in vacuum compatible versions down to 10^{-11} mbar.

Non-Magnetic Materials

Most of the **SMARSLIDE** stages are available as complete non-magnetic versions.

Cost-Effective and Future-Proof

Due to the in-house development and manufacturing of all core components, **SMARSLIDE** provides you with positioning systems of the highest quality, precision and reliability at a reasonable price. The variety of available options allow highly specific positioning solutions and future upgradability.

SMARSLIDE – Linear Piezo Stages

Overview

SMARSLIDE Nanometer Precise Linear Piezo Stages

Linear **SMARSLIDE** stages have high resolution, typical of piezos, combined with a large positioning range from a few mm to over a meter. **SMARSLIDE** includes several series of linear positioning stages. Each one was developed with our customers' requirements in mind. The full compatibility between the components of the different product lines allows to select stages with specific key features to combine them into sophisticated multi-axis systems.

SLC Series

Linear stages of the SLC series are based on linear slides with cross roller guides. **SMARSLIDE** SLC stages are characterized by their compactness, high rigidity and straightness. They are ideally suited for positioning systems where stability and high accuracy are top priorities.

CLS Series

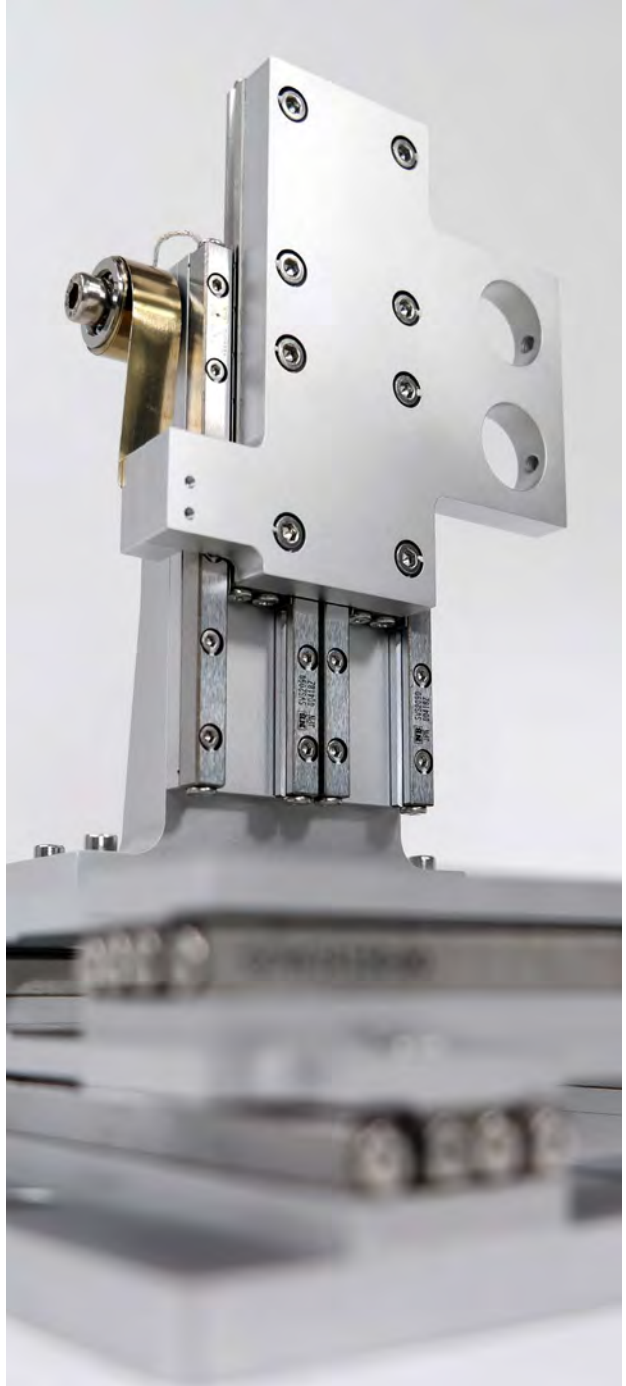
Linear stages of the CLS series are the best choice for multi-axis setups, where uninterrupted uptime is required, since they are equipped with exchangeable drive units to assure quick and easy on-site servicing.

SL Series

Linear stages of the SL series are ultra-compact and perfect for setups with space constraints or demands for extreme miniaturization.

CLL Series

Linear stages of the CLL series are particularly useful for applications where parts or components need to be placed on the same axis and moved in conjunction with each other over long ranges up to 1.5 m.



For lifting stages that need to handle heavy payloads, constant force springs are available to provide weight compensation.



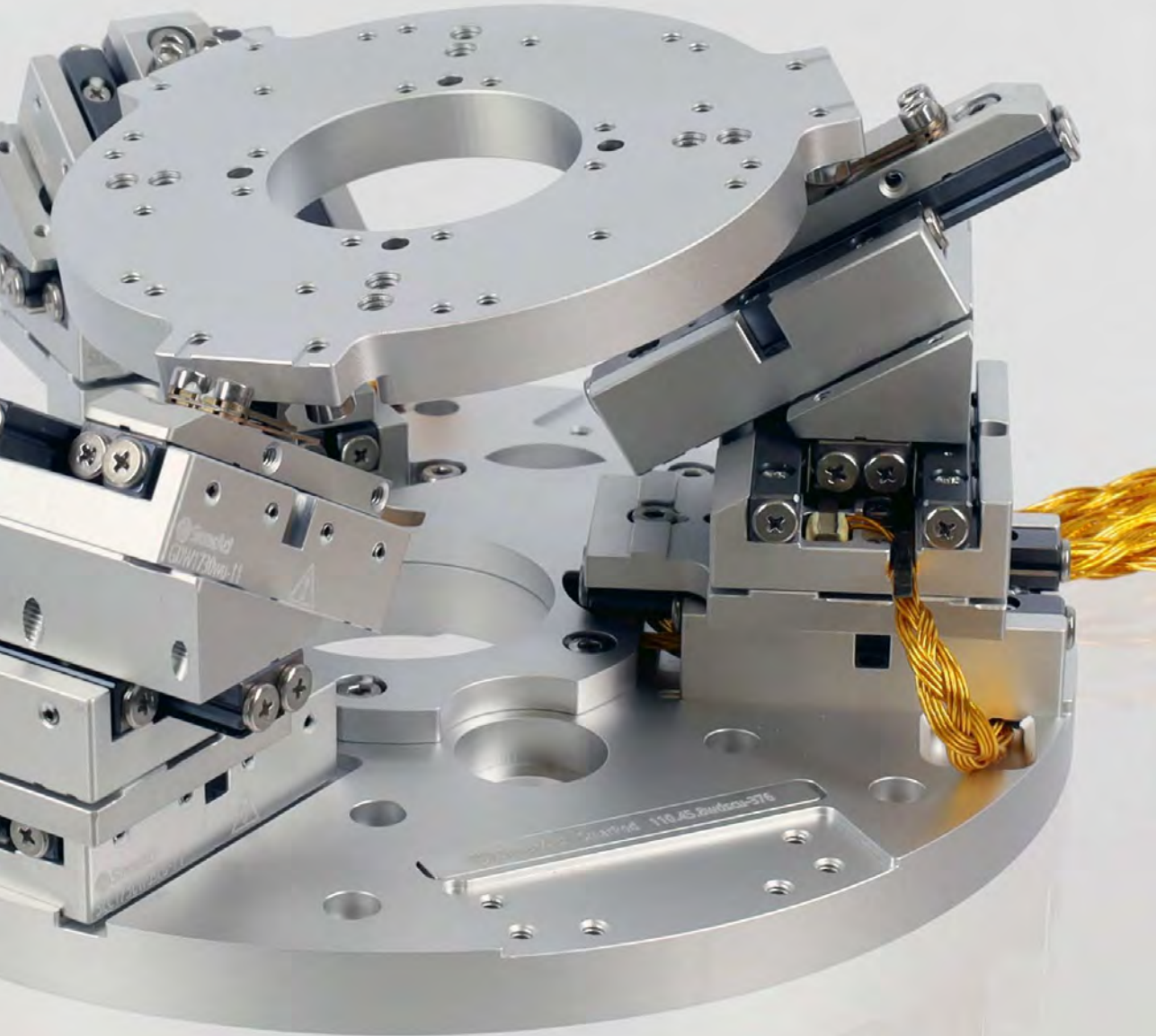
Long travel SLC series stages can be mounted on top of each other to create gantries or large XY platforms.

		SLC		CLS			SL	CLL
	Series	SLC-17	SLC-24	CLS-32	CLS-52	CLS-92	SL-06	CLL V42
	Travel [mm]	12 ... 51	16 ... 123	21 ... 51	31 ... 51	63...103	4.5 ...16	160 ... 680
	Blocking Force [N]	≥ 3.5					≥ 1.6	≥ 5
Mechanical	Max. Normal Force [N]	10 ... 30	20 ... 30	30	20		1	30
	Max. Lift Force [N]	1.5	1.5	1.5	1.0	--	0.35	1.5
	Cross Section W x H [mm]	17 x 8.5	24 x 10.5	32 x 11	52 x 14	92 x 17	11 x 5.2	60 x 16
	Velocity [mm/s]	> 20	> 20	> 20			> 10	> 15
Open-Loop	Open-Loop Resolution [nm]	MCS2: < 1 (H)CU: < 50						
Closed-Loop	Sensor Resolution [nm]	MCS2: < 1 (S), 4 (L) (H)CU: 100 (L)					--	MCS2: < 1 (S), 4 (L)
	Uni-Directional Repeatability [nm]*	MCS2: ± 40 (S,L) (H)CU: ± 200 (L) **					--	MCS2: +/- 250 (S)
Vacuum Compatibility		HV (10 ⁻⁶ mbar); UHV (10 ⁻¹¹ mbar)						

* Measured 10 mm above the top surface of the slide and along the line of symmetry. Measured over the complete travel range. An improvement can be expected for shorter travel ranges.

** This specification can be improved by using the advanced stepping mode.

Closed-loop resolution and repeatability differ depending on the sensor type selected. For more information, please see the different sensor types on page 13.



Options

Cryogenic

For applications that require very low temperatures down to the mK range, specialized versions of our SLC, SR, SRT and STT stages are available. For high-performance positioning under cryogenic conditions, SmarAct offers closed-loop cryogenic stages. Please see page 41 for further information about stages and systems for cryogenic applications.

Vacuum

Standard SMARSLIDE stages are configured to operate at atmospheric pressure. Specialized versions are available for high vacuum (HV, 10^{-6} mbar) and ultra-high vacuum (UHV, 10^{-11} mbar) applications. As a complete solution provider, SmarAct delivers fully vacuum compatible single positioning stages or multi-axis systems including vacuum compatible cabling and HV or UHV electrical feedthroughs.

Non-Magnetic Materials

Many SMARSLIDE stages are available as non-magnetic versions. In most cases their outer dimensions remain unchanged.

Position Sensors

Optical and inductive sensors can be integrated into our stages for closed-loop position control, allowing to define the desired travel distance or the target position and the velocity of the stage.

Higher Blocking Force

The blocking force is the maximum external force a SMARSLIDE stage can withstand without slipping. It corresponds to the maximum force that can be applied by the stage to another object. For certain applications where the required blocking force is higher than indicated in the tables below, the stages can be modified to increase the force without changing the external dimensions.

Constant Force Spring

If the application requires the stage to lift a constant, vertically arranged load, a constant force spring can be integrated to serve as a counterweight and thus increase the maximum force.

U-Shaped Base

SLC series stages are also available with U-shaped base instead of the rectangular standard bases. This special shape increases the mechanical strength of the stage. Due to the different dimensions of the U-shaped base, the width of the stage itself will be increased by 6 mm. Nevertheless, the mounting hole pattern remains the same as for the standard bases.

Sensor Type	S	SC	L	LC	I
Working Principle	Optical				Inductive
Resolution [nm]	< 1		4		< 50
Reference Positions	Single reference mark	Multiple reference marks	Single reference mark	Multiple reference marks	Endstop
Control System Compatibility	MCS2, SDC2	MCS2	MCS2, SDC2, CU	MCS2, CU	MCS2, EMS, CU
Vacuum Compatibility	Down to 10^{-11} mbar		Atmospheric pressure only		Down to 10^{-6} mbar

SMARSLIDE – Linear Piezo Stages

SLC-17 Series



	SLC-1720	SLC-1730	SLC-1740	SLC-1750	SLC-1760	SLC-1770	SLC-1780
Mechanical							
Travel [mm]	12	21	26	31	41	46	51
Scan Range [µm]	> 1.3						
Blocking Force [N]	≥ 3.5						
Max. Normal Force [N]	10	20					30
Max. Lift Force [N]	> 1.5						
Dimensions [mm], L x W x H	22 x 17 x 8.5	30 x 17 x 8.5	40 x 17 x 8.5	50 x 17 x 8.5	60 x 17 x 8.5	70 x 17 x 8.5	80 x 17 x 8.5
Weight [g]	13	18	25	31	37	43	49
Open-Loop							
Velocity [mm/s]	> 20						
Open-Loop Resolution [nm]	< 1						
Closed-Loop							
Sensor Resolution [nm]	MCS2: < 1 (S), 4 (L) (H)CU: 100 (L)						
Uni-Directional Repeatability [nm]*	MCS2: ± 40 (S,L) (H)CU: ± 200 (L)**						
Material Options	Aluminum base as standard; steel base (-ST); titanium base (-TI); black anodized (-BK)						
Mechanical Options	U-shaped base for higher mechanical strength (-W); width is 6mm larger; cage-creep-free guideways (-Z)						
Performance Options	Higher blocking force (-D): +1.5 N						
Cryogenic Option	Yes						
Vacuum Options	HV (10 ⁻⁶ mbar); UHV/UHVT (10 ⁻¹¹ mbar)						
Non-Magnetic Option	Yes, changes of the slide hole pattern apply: all threaded holes						

* Measured 10 mm above the top surface of the slide and along the line of symmetry. Measured over the complete travel range. An improvement can be expected for shorter travel ranges.

** This specification can be improved by using the advanced stepping mode.

Closed-loop resolution and repeatability differ depending on the sensor type selected. For more information, please see the different sensor types on page 13.

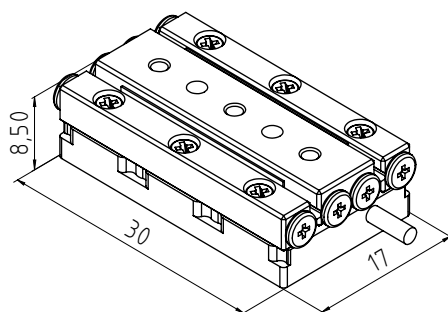
SMARSLIDE – Linear Piezo Stages SLC-17 Series

Linear positioners of the SLC series are very rigid and therefore ideally suited for nanopositioning systems where stability and high accuracy are top priorities.

The SLC-17 series with a width of only 17 mm and a height of only 8.5 mm is the perfect choice for applications where space is at a premium and maximum compactness is key. Travel ranges are available up to 51 mm. The SLC-24 offers even more rigidity and travel ranges up to 123 mm at a still very small cross section of 24 x 10.5 mm². For detailed specifications and available options see the tables on the left for the SLC-17 series and the ones on the following pages for the SLC-24 series.



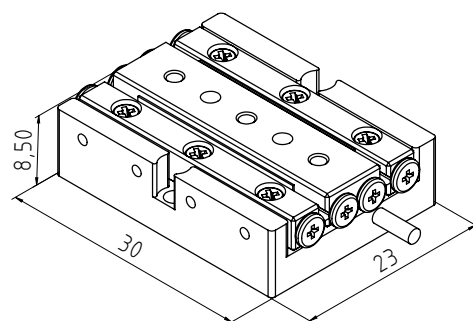
SLC-1730 linear piezo stage with standard base.



Detailed technical drawings and 3D models can be found on our website.



SLC-1730 with U-shaped base (option -W) for higher mechanical strength, which is highly recommended for non-magnetic stages, UHV stages that are baked out and stages that are subject to torques.



Detailed technical drawings and 3D models can be found on our website.

SMARSLIDE – Linear Piezo Stages

SLC-24 Series



	SLC-2430	SLC-2445	SLC-2460	SLC-2475
Mechanical				
Travel [mm]	16	29	35	49
Scan Range [μm]	> 1.3			
Blocking Force [N]	≥ 3.5			
Max. Normal Force [N]	30			
Max. Lift Force [N]	1.5			
Dimensions [mm], L x W x H	30 x 24 x 10.5	45 x 24 x 10.5	60 x 24 x 10.5	75 x 24 x 10.5
Weight [g]	37	55	73	91
Open-Loop				
Velocity [mm/s]	> 20			
Open-Loop Resolution [nm]	MCS2: < 1 (H)CU: < 50			
Closed-Loop				
Sensor Resolution [nm]	MCS2: < 1 (S), 4 (L) (H)CU: 100 (L)			
Uni-Directional Repeatability [nm]*	MCS2: ± 40 (S,L) (H)CU: ± 200 (L) **			
Material Options	Aluminum base as standard; Steel base (-ST); Titanium base (-TI); Black anodized (-BK)			
Mechanical Options	U-shaped base for higher mechanical strength (-W): width is 6mm larger; cage-creep-free guideways (-Z)			
Performance Option	Higher blocking force (D): +1.5 N			
Cryogenic Option	Yes			
Closed-Loop Cryogenic Option	Yes. Changes to the external dimensions apply. See page for details.			
Vacuum Options	HV (10 ⁻⁶ mbar); UHV (10 ⁻¹¹ mbar)			
Non-Magnetic Option	Yes, changes of the slide hole pattern apply: all threaded holes			

* Measured 10 mm above the top surface of the slide and along the line of symmetry. Measured over the complete travel range. An improvement can be expected for shorter travel ranges.

** This specification can be improved by using the advanced stepping mode.

Closed-loop resolution and repeatability differ depending on the sensor type selected. For more information, please see the different sensor types on page 13.

Linear stages of the SLC-24 series are even more rigid than the SLC-17 series and therefore ideally suited for tasks where stability and robustness are top priorities. The stage's rigidity can be increased even further by choosing the W option which means an U-shaped baseplate.

		SLC-2490	SLC-24105	SLC-24120	SLC-24150	SLC-24180
Mechanical	Travel [mm]	63	69	83	103	123
	Scan Range [μm]					
	Blocking Force [N]	≥ 3.5				
	Max. Normal Force [N]	30				
	Max. Lift Force [N]	1.5				
	Dimensions [mm], L x W x H	90 x 24 x 10.5	105 x 24 x 10.5	120 x 24 x 10.5	150 x 24 x 10.5	180 x 24 x 10.5
Weight [g]	108	126	144	180	215	
Open-Loop	Velocity [mm/s]	> 20				
	Open-Loop Resolution [nm]	MCS2: < 1 (H)CU: < 50				
Closed-Loop	Sensor Resolution [nm]	MCS2: < 1 (S), 4 (L) (H)CU: 100 (L)				
	Uni-Directional Repeatability [nm] *	MCS2: ± 40 (S,L) (H)CU: ± 200 (L) **				
Material Options		Aluminum base as standard: Steel base (-ST); Titanium base (-TI); Black anodized (-BK)				
Mechanical Option		U-shaped base for higher mechanical strength (-W): width is 6mm larger; cage-creep-free guideways (-Z)				
Performance Option		Higher blocking force (-D): +1.5 N				
Cryogenic Option		--				
Closed-Loop Cryogenic Option		--				
Vacuum Options		HV (10 ⁻⁶ mbar); UHV (10 ⁻¹¹ mbar)				
Non-Magnetic Option		Yes, changes of the slide hole pattern apply: all threaded holes				

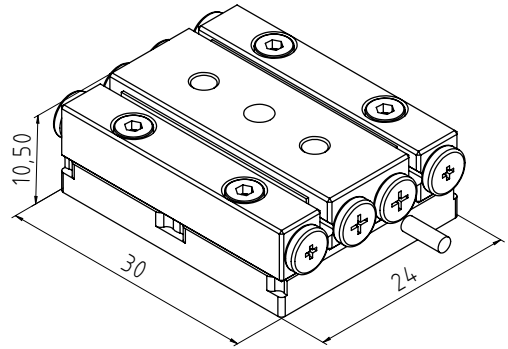
* Measured 10 mm above the top surface of the slide and along the line of symmetry. Measured over the complete travel range. An improvement can be expected for shorter travel ranges.

** This specification can be improved by using the advanced stepping mode.

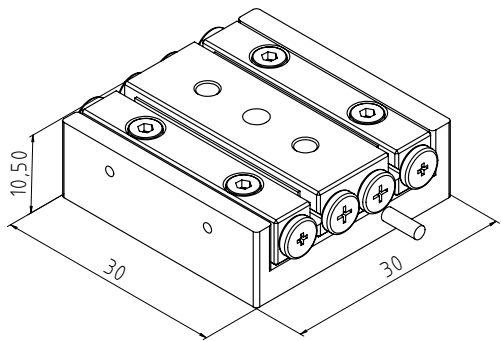
Closed-loop resolution and repeatability differ depending on the sensor type selected. For more information, please see the different sensor types on page 13.

SMARSLIDE – Linear Piezo Stages

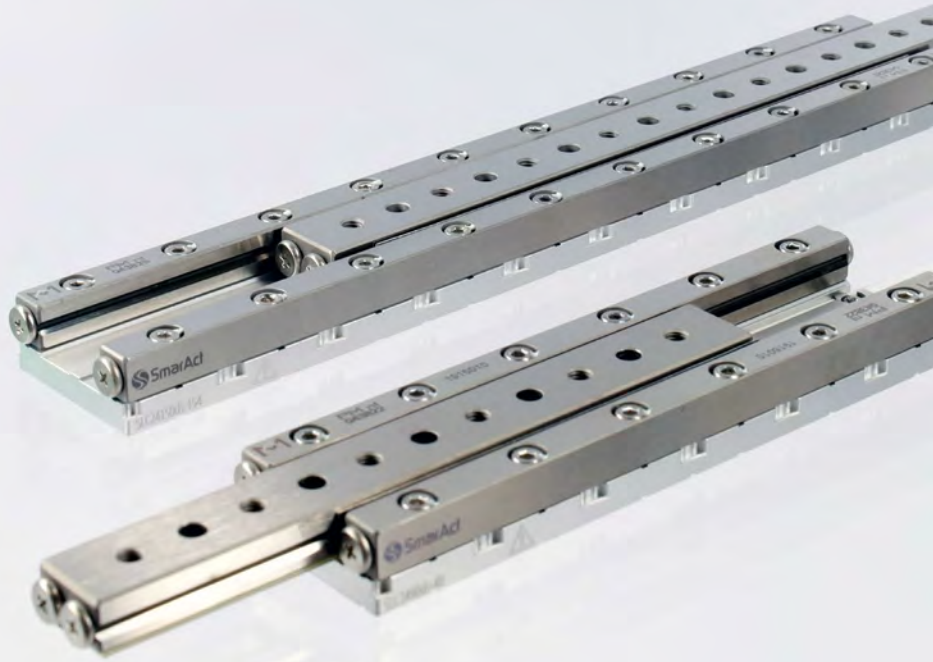
SLC-24 Series



Detailed technical drawings and 3D models can be found on our website.



Detailed technical drawings and 3D models can be found on our website.



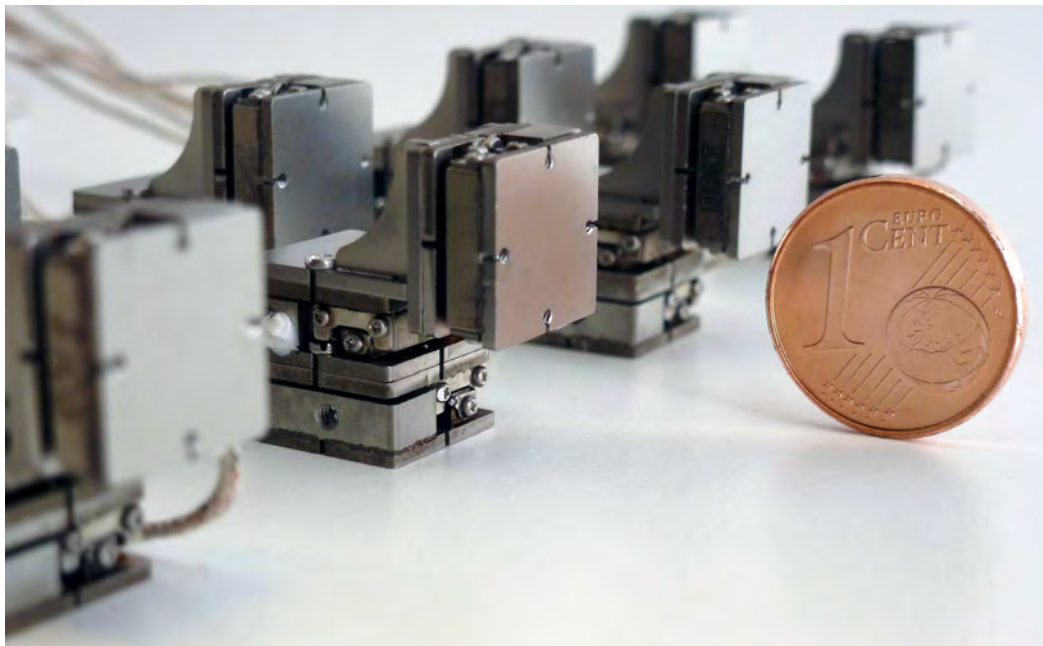
SMARSLIDE – Linear Piezo Stages

SL Series

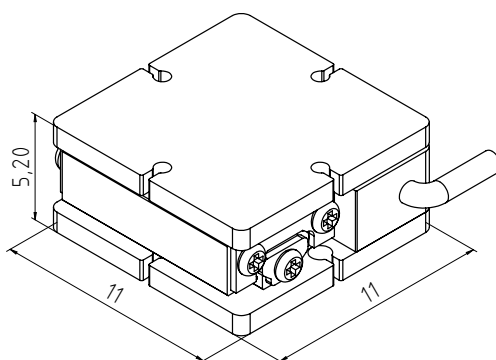


Linear stages of the SL series are ultra-compact and specifically designed for setups with space constraints or requirements for extreme miniaturization. While maintaining their miniature size, the stages offer comparatively long travel ranges and can be combined to build complex multi-axis systems.

	SL-0610	SL-0620	SL-0630
Travel [mm]	4.5	11	16
Mechanical	Blocking Force [N]	≥ 1.6	
	Max. Normal Force [N]	1	
	Max. Lift Force [N]	0.35	
	Dimensions [mm], L x W x H	11 x 11 x 5.2	21 x 11 x 5.2
Open-Loop	Velocity [mm/s]	> 10	
	Open-Loop Resolution [nm]	MCS2: < 1 (H)CU: < 50	
Material Options	Steel base (-ST) as standard		
Vacuum Options	HV (10 ⁻⁶ mbar); UHV (10 ⁻¹¹ mbar)		



XYZ positioning systems built from three SL-0610 linear stages.



Detailed technical drawings and 3D models can be found on our website.

Complex positioning systems like the **SMARPOD** CLS-32 (a parallel kinematic with 6 DoF), which are used for many positioning tasks in science and industry, benefit most from exchangeable drive units, because their axis arrangement remains unchanged and they do not have to relearn poses after replacing a drive unit. This is useful for preventive maintenance, for example.



SMARSLIDE – Linear Piezo Stages

Stages with Exchangeable Drive Units



SMARSLIDE's exchangeable drive units (EDUs) are specifically designed for industrial and scientific applications where the time for preventive maintenance must be as short as possible. The stick-slip piezo drive is housed in a robust drive unit that you can easily replace yourself. With SMARSLIDE's EDUs, downtime for piezo motor replacement is reduced to a few minutes. The unique and patented drive units are available for linear stages of the CLS series, CGO goniometer stages, CHS high load stages and long travel rail-based CLL stages. SMARSLIDE's exchangeable drive units provide you with direct benefits in various ways:

Plannable On-Site Service

The exchangeable drive units are factory tested and preset. To replace the unit, only two screws have to be removed which makes replacement a very simple task.

Due to the EDU's simplicity, their exchange can be planned and synchronized with other maintenance tasks. Since the EDUs are supplied in sealed and stockable packaging, they can be stored safely until the next maintenance.

Reduced Downtime

Stages with EDUs do not have to be removed from the positioning system when replacing a drive unit. Therefore, taught poses, stored positions and calibration data remain valid. Complete systems can remain assembled and payload does not need to be removed.

Cost and Time Efficiency

Compared to the cost of buying complete stages as spare parts, EDUs carry only a fraction of the cost. Tedious repair or service shipments can be dispensed with.

Compatibility

EDUs are available in SmarAct product series of CLS linear stages, CGO goniometer stages, CHS high load stages and rail-based CLL stages. Complete positioning systems, from serial multi-axis systems up to parallel kinematics such as the hexapod-like SMARPOD can also be equipped with SMARSLIDE's EDUs. This allows you to keep a stock of one type of EDU for multiple types of positioners and systems.

SMARSLIDE – Linear Piezo Stages

CLS Series



CLS stages can be combined to an XY stage without the need for connecting elements. Their mounting hole pattern is perfectly matched to mount our rotation stages, high load stages and goniometers. They are the perfect option when modularity and easy configuration are the top level requirements. Example setups of multi-axis systems and an overview about the range of mechanical components like adapter plates, breadboard adapters and

brackets to easily setup multi-axis systems can be found on page 66 and following.

Here we are presenting stages of the CLS series in standardized length. If your specific application requires other length and travel ranges, please feel free to contact us to discuss possible configurations.

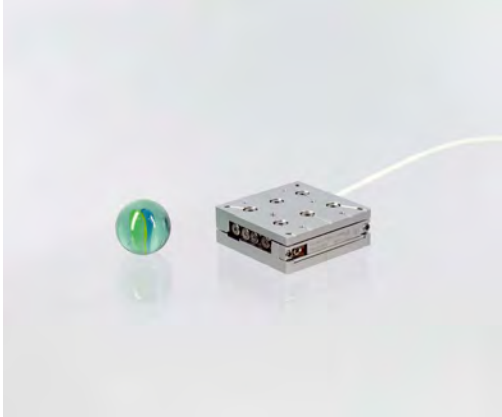
	CLS-3232	CLS-3252	CLS-3282	CLS-5252	CLS-5282	CLS-9292	CLS-92152
Travel [mm]	21	31	51	31	51	63	103
Scan Range [µm]	> 1.3						
Blocking Force [N]	≥ 3.5						
Max. Normal Force [N]	30			20			
Max. Lift Force [N]	> 1.5			> 1.0		--	
Dimensions [mm], L x W x H	32 x 32 x 11	52 x 32 x 11	82 x 32 x 11	52 x 52 x 14	82 x 52 x 14	92 x 92 x 17	152 x 92 x 17
Weight [g]	33	54	87	94	157	357	591
Open-Loop Velocity [mm/s]	> 20						
Open-Loop Resolution [nm]	< 1						
Closed-Loop Sensor Resolution [nm]	MCS2: < 1 (S), 4 (L) (H)CU: 100 (L)						
Closed-Loop Uni-Directional Repeatability [nm]*	MCS2: ±40 (S,L) (H)CU: ± 200 (L) **						
Material Options	Aluminum base as standard; Titanium base (-TI)						
Vacuum Options	HV (10 ⁻⁶ mbar); UHV (10 ⁻¹¹ mbar)						

* Measured 10 mm above the top surface of the slide and along the line of symmetry. Measured over the complete travel range. An improvement can be expected for shorter travel ranges.

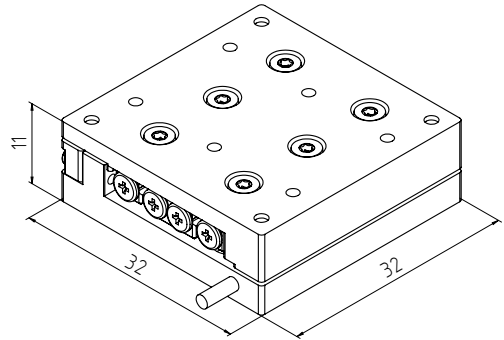
** This specification can be improved by using the advanced stepping mode.

Closed-loop resolution and repeatability differ depending on the sensor type selected. For more information, please see the different sensor types on page 13.

SMARSLIDE – Linear Piezo Stages CLS Series



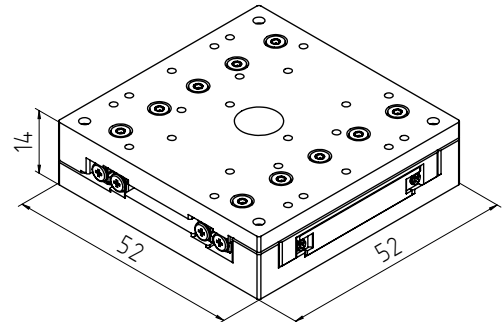
CLS-3232 is the smallest linear stage with exchangeable drive unit.



Detailed technical drawings and 3D models can be found on our website.



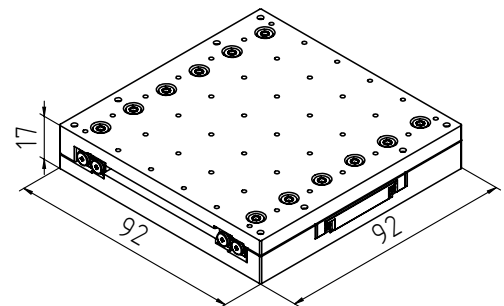
CLS-5252 linear stage with exchangeable drive unit.



Detailed technical drawings and 3D models can be found on our website.



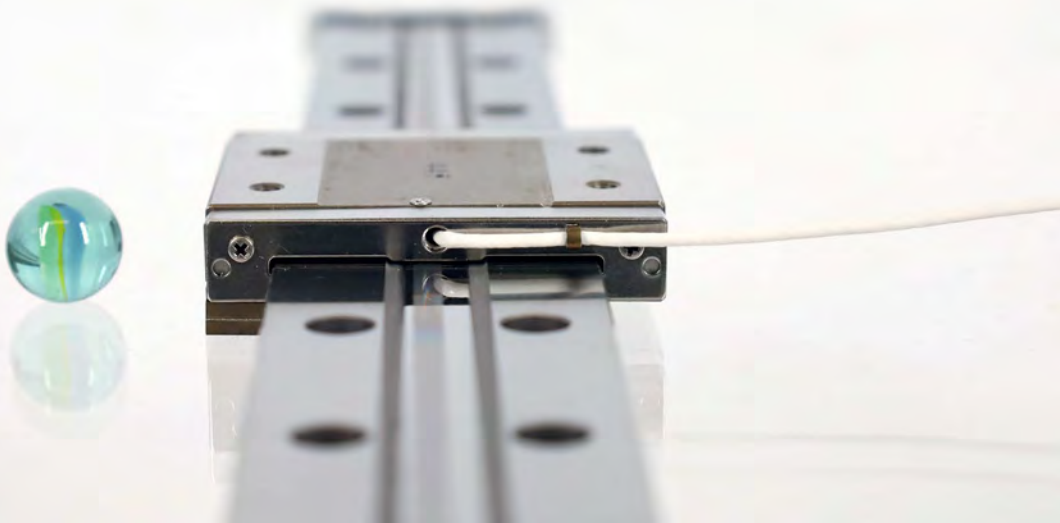
CLS-9292 linear stage with exchangeable drive unit.



Detailed technical drawings and 3D models can be found on our website.

SMARSLIDE – Linear Piezo Stages

CLL Series



Linear **SMARSLIDE** stages of the CLL series are based on recirculating ball slides running on a fixed rail. In combination with rails of different lengths these slides make the stages an optimal solution for precise positioning over long distances in lim-

ited spaces. Multiple slide configurations make the CLL a very versatile positioning solution. For easy service they are equipped with **SMARSLIDE** exchangeable drive units. A number of CLL stages are also available in HV- and UHV-compatible versions.

		CLL12	CLL42
Mechanical	Rail Length [mm]	100 ... 475	160 ... 680
	Travel [mm]	14 ... 389	99 ... 619
	Blocking Force [N]	≥ 5	
	Max. Normal Force [N]	30	
	Max. Lift Force [N]	1.5	
	Dimensions [mm], W x H	60 x 16 (open-loop carriage)	
	Weight [g]	Length-dependent	
Open-Loop	Velocity [mm/s]	> 15	
	Open-Loop Resolution [nm]	MCS2: < 1 (H)CU: < 50	
Closed-Loop	Sensor Resolution [nm]	MCS2: < 1 (S), 4 (L)	
	Uni-Directional Repeatability [nm]*	MCS2: ± 100 (S)	
Material Options		--	Multiple carriages; Counterbores; Tapped holes (M4)
Vacuum Options		HV (10 ⁻⁶ mbar)	HV (10 ⁻⁶ mbar); UHV (10 ⁻¹¹ mbar)

* Measured 10 mm above the top surface of the slide and along the line of symmetry. Measured over the complete travel range. An improvement can be expected for shorter travel ranges.

Closed-loop resolution and repeatability differ depending on the sensor type selected. For more information, please see the different sensor types on page 13.

CLL Accessories

Various accessories are available to customize your CLL system to your specific positioning tasks. You are always welcome to contact our application specialists to find the perfect solution. Some example accessories include:

Multiple Carriages

It is possible to place multiple slides on the same rail and move them independently. This allows for fully motorized optical bench setups. Passive carriages with clamping screw locks to secure their position on the rail are also available to mount fixed parts of your optical setup.

Endstop Brackets

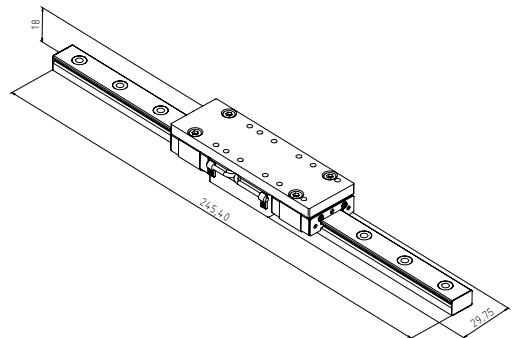
Threaded endstop brackets allow to flexibly limit the slide travel along the rails.

Breadboard Adapters

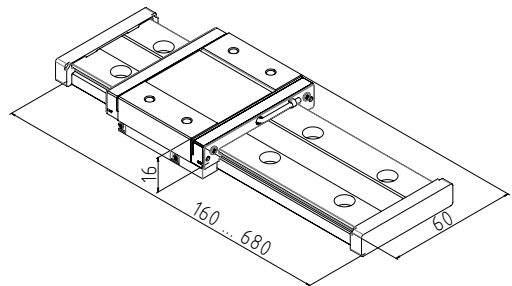
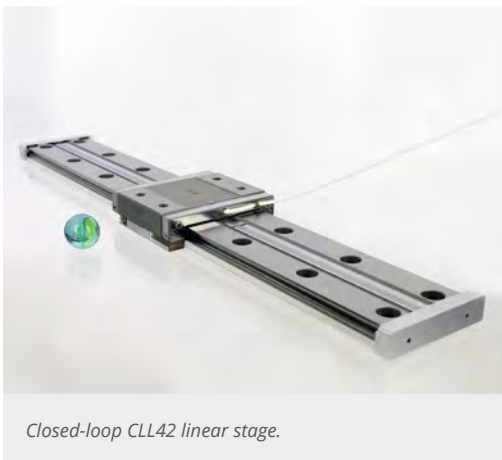
Mounting adapters are available for every common hole pattern of breadboards and optical tables. For long rails, flexure structures are available to compensate for thermal expansion.

Slide Adapters

Various mounts and adapters are available to attach sub-stages or optomechanical components to the slides.



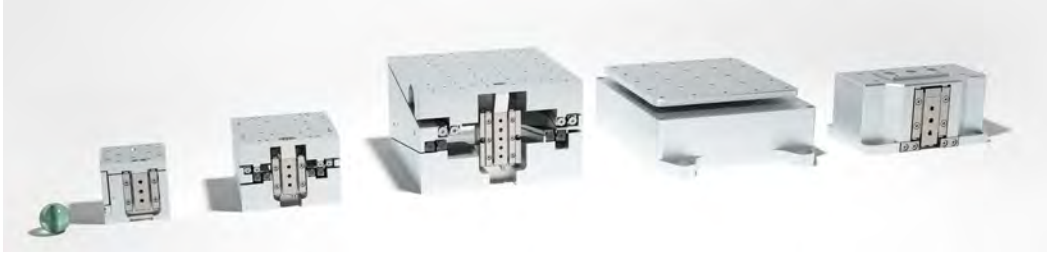
Detailed technical drawings and 3D models can be found on our website.



Detailed technical drawings and 3D models can be found on our website.

SMARSLIDE – High Load Stages

Overview



Linear **SMARSLIDE** stages of the CHS and SHL series are specifically designed to handle heavy payloads. The mechanical design is based on an actuated wedge, which guarantees highest resolution of the stages motion. A separate guideway assures a straight movement along the load direction and allows an integration of a position sensor for direct position feedback and closed-loop operation. CHS stages feature matching hole patterns with many linear and rotation stages and can be easily integrated into complex multi-axis systems. They

are equipped with **SMARSLIDE** exchangeable drive units for easy maintenance. While being able to handle high payloads, **SMARSLIDE** high load stages remain very compact and are suitable for setups with space constraints. CHS stages intended for vertical lifting movement can be equipped with different additional constant force springs (CFS) to further increase the payload. Please feel free ask our application specialists for the best configuration for your specific system payload.

	CHS-3232-1D-5	CHS-5237-1D-10	CHS-9257-1D-15	SHL-3D5N-5	SHL-1D80N-1	
Mechanical	Degrees of Freedom	1	1	1	3	1
	Travel [mm]	5	10	20	3	1
	Max. Lift Force [N]	5	10	15*	5 (all directions)	80
	Dimensions [mm], L x W x H	32 x 32 x 32	52 x 52 x 37	92 x 92 x 57	100 x 140 x 40	41 x 86 x 50
	Weight [g]	100	270	935	650	340
Open-Loop	Velocity [mm/s]	> 5	> 2		> 5	> 1
	Open-Loop Resolution [nm]	MCS2: < 1				
Closed-Loop	Sensor Resolution [nm]	MCS2: < 1 (S), 4 (L) (H)CU: 100 (L)				
	Uni-Directional Repeatability [nm]**	MCS2: ± 40 (S,L) (H)CU: ± 200 (S, L)				
Material Options	Aluminum base as standard; Steel base (-ST); Titanium base (-TI); Black anodized (-BK)					
Vacuum Options	HV (10 ⁻⁶ mbar); UHV (10 ⁻¹¹ mbar)					

* Max. lift force can be increased upon request.

** Measured over the complete travel range. Lower values can be expected for shorter travel ranges.

Closed-loop resolution and repeatability differ depending on the sensor type selected. For more information, please see the different sensor types on page 13.

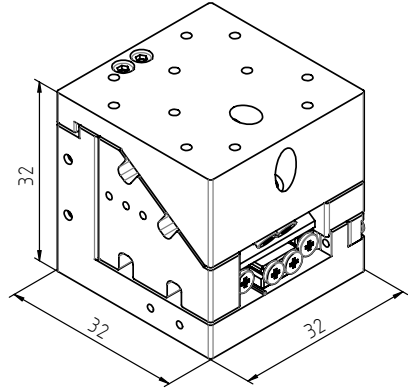


SMARSLIDE – High Load Stages

CHS Series



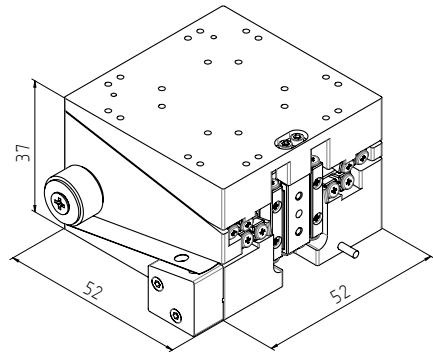
CHS-3232 high load stage featuring the exchangeable drive unit.



Detailed technical drawings and 3D models can be found on our website.



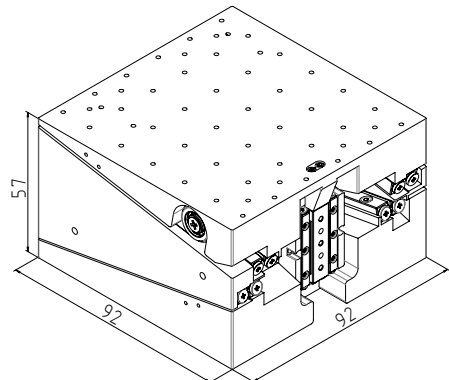
CHS-5237 high load stage featuring the exchangeable drive unit.



Detailed technical drawings and 3D models can be found on our website.



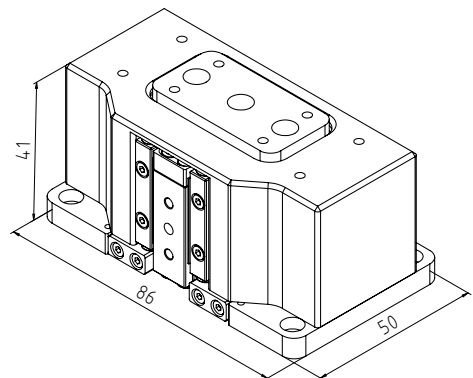
CHS-9257 high load stage featuring the exchangeable drive unit.



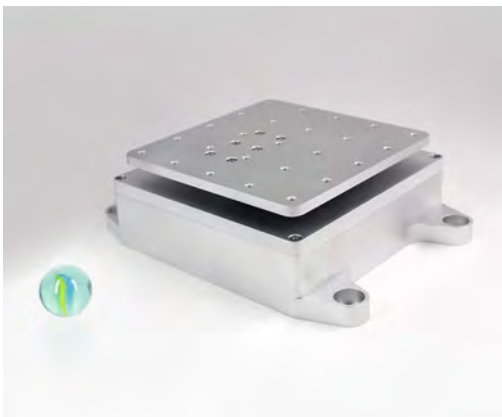
Detailed technical drawings and 3D models can be found on our website.



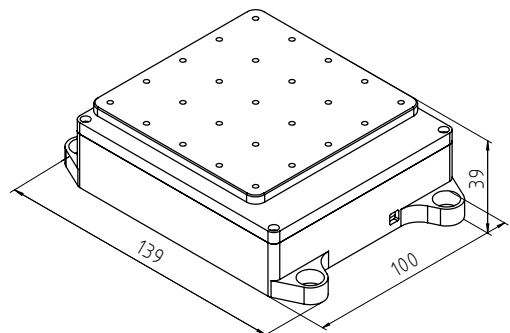
SHL-1D80N-1 high load stage is able to lift 80 N.



Detailed technical drawings and 3D models can be found on our website.



SHL-3D5N-5 high load stage with 3 degrees of freedom.



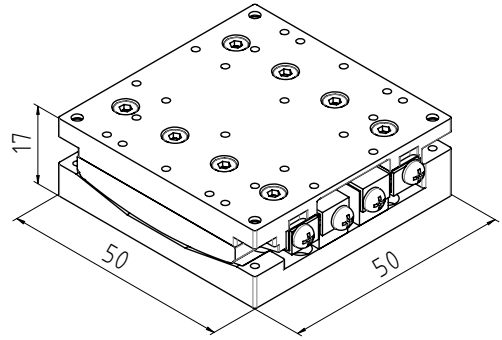
Detailed technical drawings and 3D models can be found on our website.

SMARSLIDE – Goniometer Stages

CGO Series



CGO goniometer stage with exchangeable drive unit.



Detailed technical drawings and 3D models can be found on our website.

	CGO-60.5	CGO-77.5	
Mechanical	Travel [°]	± 5	
	Blocking Torque [Ncm]	30	38
	Max. Normal Force [N]	5	
	Dimensions [mm], L x W x H	50 x 50 x 17	
	Weight [g]	~ 140	
	Center of Rotation [mm]	60.5	77.5
Open-Loop	Angular Velocity [°/s]	> 4	
	Open-Loop Resolution [μ°]	< 1	
Closed-Loop	Sensor Types	S, L	
	Sensor Resolution [μ°]	MCS2: < 1 (S), 8 (L) (H)CU: 100 (L)	
	Uni-Directional Repeatability [μ°] *	MCS2: ± 100 (S,L) (H)CU: ± 250 (L)**	
Material Options	Aluminum as standard; Steel base (-ST); Titanium base (-TI)		
Mechanical Options	Cage-creep-free guideways as standard		
Vacuum Compatibility	HV (10 ⁻⁶ mbar), UHV (10 ⁻¹¹ mbar)		

* Measured at the center of rotation. Measured over the complete travel range. An improvement can be expected for shorter travel ranges.

** This specification can be improved by using the advanced stepping mode.

Closed-loop resolution and repeatability differ depending on the sensor type selected. For more information, please see the different sensor types on page 13.

The **SMARSLIDE** goniometer stages from the CGO series are ideally suited for applications that require very precise rotation over small angles ($\pm 5^\circ$). They are available with two different radii that can be stacked directly to form an extremely compact and stiff Euler goniometer with a common center of rotation. The CGO series features the exchangeable drive unit (EDU) and a compatible hole pattern that allows easy integration with linear or rotation stages into multi-dimensional serial systems.



SMARSLIDE – Rotation Stages

Overview

Based on the SMARSLIDE piezo drive technology, rotation stages are available. They can be easily combined with each other or with other SmarAct positioning stages to form more complex setups like gimbals, rotatable Eulerian cradles, multi-axis or multi-rotation positioning systems. SMARSLIDE rotation stages allow for continuous and mechanically unlimited rotation. The rotation can be mechanically limited if it is necessary to avoid collisions or tearing cables of devices installed on top. SmarAct offers various designs of rotation stages. They differ by their outer dimensions, aperture

size, available torque, velocity precision and resolution. Different bearing concepts and materials allow to select the best suited stage for the application: For example, ruggedness and load capacity as in the case of steel crossed-roller bearings, or lowest possible runout error and UHV compatibility with our high-precision ceramic ball bearings which can also be used to build completely non-magnetic positioners. Our application specialists are happy to assist you with selecting the right stage for your application.

	SR-1908	SR-2013	SR-2812	SR-3211	SR-4011	SR-4513	
Mechanical	Travel [°]	∞					
	Blocking Torque [Ncm]	≥ 0.5	≥ 0.5	≥ 3	≥ 2	≥ 3	≥ 5
	Max. Normal Force [N]	5	3	3	3	10	20
	Dimensions [mm], L x W x H	25 x 20 x 8.5	22.5 x 20 x 10.2	37.5 x 30 x 12	32 x 32 x 11	40 x 40 x 11	45 x 45 x 12.5
	Weight [g]	13	11	35	35	60	89
	Aperture [mm]	8	--	9	--	9	8
Open-Loop	Angular Velocity [°/s]	> 45		> 30			
	Open-Loop Resolution [μ°]	< 3	< 4	< 2	< 4	< 2	
Closed-Loop	Sensor Types	--	S		S, L		
	Sensor resolution [μ°]	--	MCS2: 25 (S)	MCS2: 25 (S), 100 (L) (H)CU: 100 (L)	MCS2: 15 (S), 60 (L) (H)CU: 100 (L)		
Material Options	--	Aluminum as standard; Steel base (-ST); Titanium base (-TI);					
Performance Options	--	--	Higher blocking torque				
Vacuum Options	HV (10 ⁻⁶ mbar)	HV (10 ⁻⁶ mbar); UHV (10 ⁻¹¹ mbar)			HV (10 ⁻⁶ mbar)		
Non-Magnetic Option	--	Yes (-NM)			--	--	

Closed-loop resolution and repeatability differ depending on the sensor type selected. For more information, please see the different sensor types on page 13.

Rotation stages can also be customized to fit special application requirements.

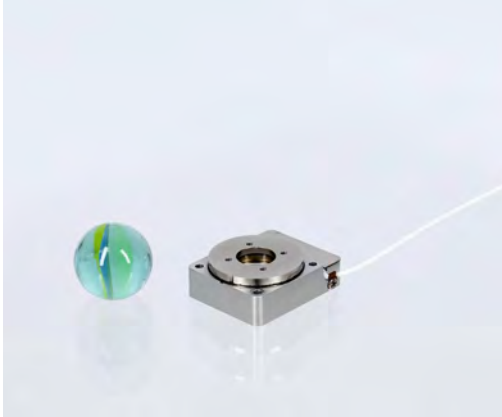


	SR-5014	SR-5714	SR-5714C	SR-7012	SR-9219	SR-9219C	SR-12012	
Mechanical	Travel [°]	∞						
	Blocking Torque [Ncm]	≥ 5	≥ 7			≥ 10	≥ 10	≥ 15
	Max. Normal Force [N]	20	25	25	25	25	25	20
	Dimensions [mm], L x W x H	50 x 50 x 14	57 x 57 x 14	57 x 57 x 13.75	70 x 70 x 12	92 x 92 x 19	92 x 92 x 19	120 x 120 x 12
	Weight [g]	100	110	105	100	450	250	320
	Aperture [mm]	8	25	25	30	27	30	82
Open-Loop	Angular Velocity [°/s]	> 30	> 15				> 5	
	Open-Loop Resolution [μ°]	< 2	< 1.5		< 1	< 1	< 1	< 0.5
Closed-Loop	Sensor Types	S, L		S	S, L		S	S
	Sensor resolution [μ°]	MCS2: 15 (S), 60 (L) (H)CU: 100 (L)		MCS2: 15 (S)	MCS2: 15 (S), 60 (L) (H)CU: 100 (L)		MCS2: 15 (S)	MCS2: 5 (S)
Material Options	Aluminum as standard; Steel base (-ST); Titanium base (-TI);							
Performance Options	Higher blocking torque							
Vacuum Options	HV (10 ⁻⁶ mbar)		HV (10 ⁻⁶ mbar); UHV (10 ⁻¹¹ mbar)		HV (10 ⁻⁶ mbar)		HV (10 ⁻⁶ mbar); UHV (10 ⁻¹¹ mbar)	
Non-Magnetic Option	--		Yes (-NM)		--		Yes (-NM)	

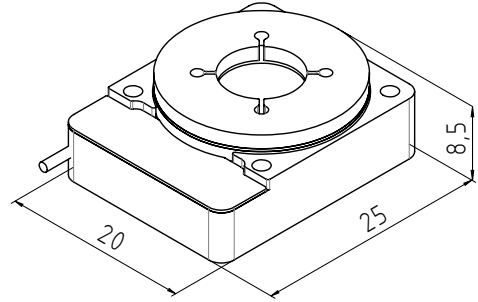
Closed-loop resolution and repeatability differ depending on the sensor type selected. For more information, please see the different sensor types on page 13.

SMARSLIDE – Rotation Stages

SR Series



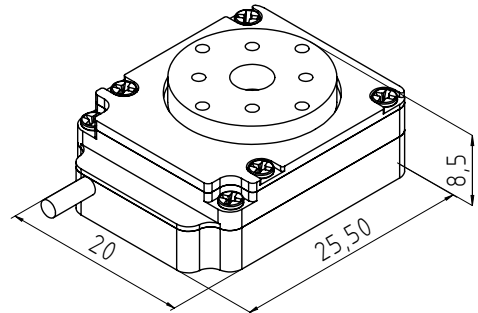
SR-1908 is a compact open-loop rotation stage with stainless-steel bearing.



Detailed technical drawings and 3D models can be found on our website.



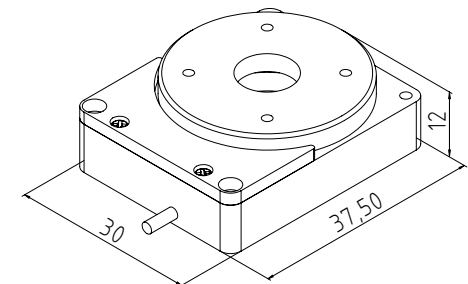
SR-2013 is SmarAct's smallest rotation stage with closed-loop option featuring high-accuracy ceramic bearing.



Detailed technical drawings and 3D models can be found on our website.



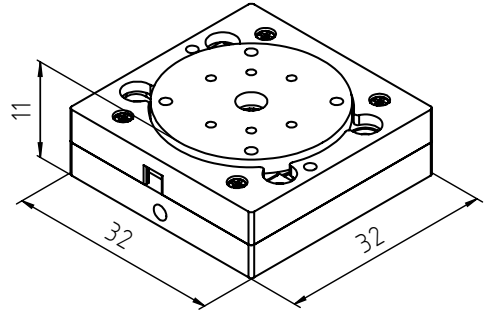
SR-2812 is SmarAct's smallest closed-loop stage with an aperture (9 mm) and high-accuracy ceramic bearing.



Detailed technical drawings and 3D models can be found on our website.



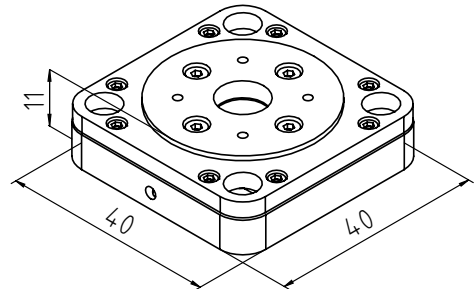
SR-3211 fits perfect for modular systems with CLS-32 linear stages and features a high-accuracy ceramic bearing.



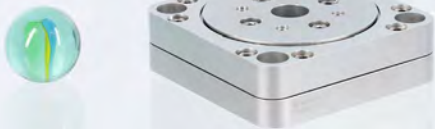
Detailed technical drawings and 3D models can be found on our website.



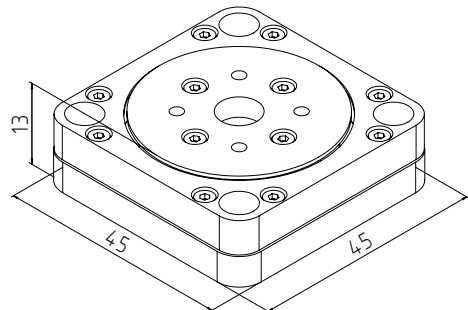
SR-4011 is very robust at compact footprint thanks to high-load stainless-steel bearing and has a 9 mm aperture.



Detailed technical drawings and 3D models can be found on our website.



SR-4513 also offers a high-load stainless-steel bearing but features higher load and torque ratings than the SR-4011. The aperture is slightly smaller (8 mm).



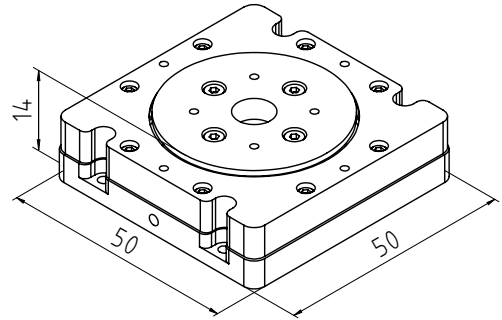
Detailed technical drawings and 3D models can be found on our website.

SMARSLIDE – Rotation Stages

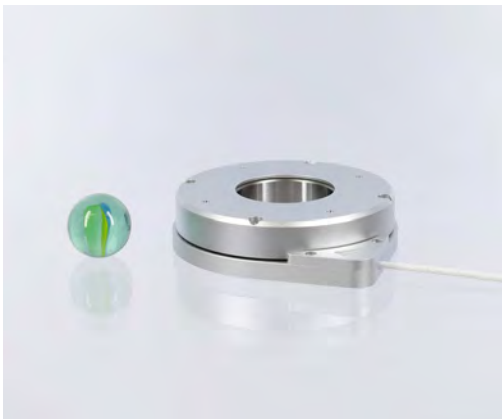
SR Series



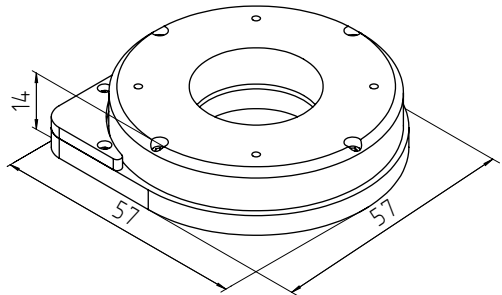
SR-5014 is very robust and cost-effective. It fits perfect for integration into modular systems with CLS-52 stages and offers 8 mm aperture..



Detailed technical drawings and 3D models can be found on our website.



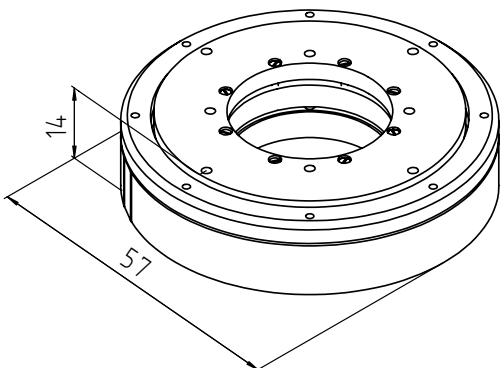
SR-5714 is very robust with 25 N load rating. The large aperture (25 mm) allows a wide range of applications.



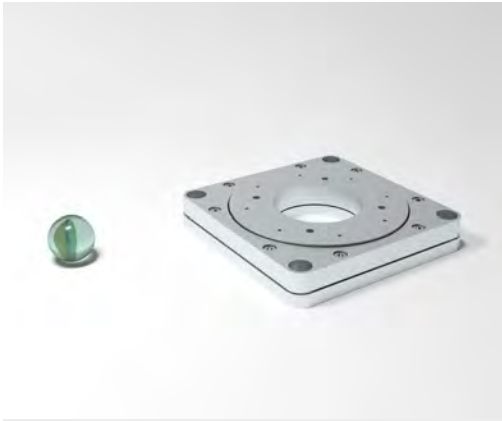
Detailed technical drawings and 3D models can be found on our website.



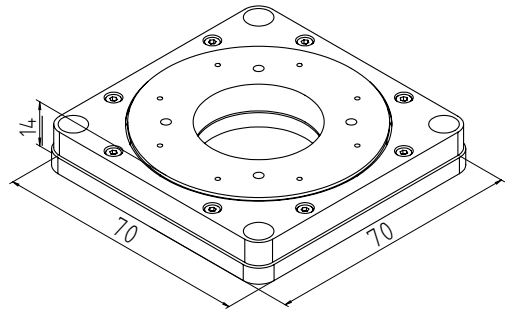
SR-5714C with ceramic bearing for applications where low runout errors are important, even down to UHV conditions. It's aperture has a diameter



Detailed technical drawings and 3D models can be found on our website.



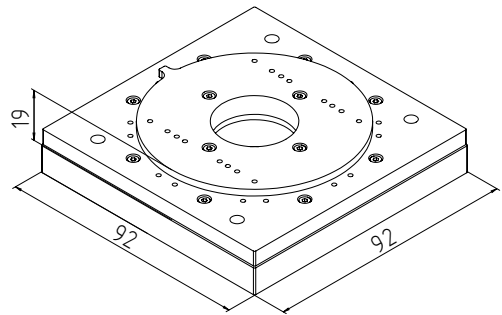
SR-7012 is the most versatile rotation stage with a large aperture (30 mm), low height and high load rating.



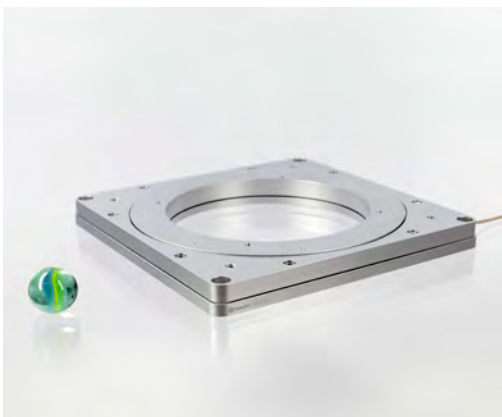
Detailed technical drawings and 3D models can be found on our website.



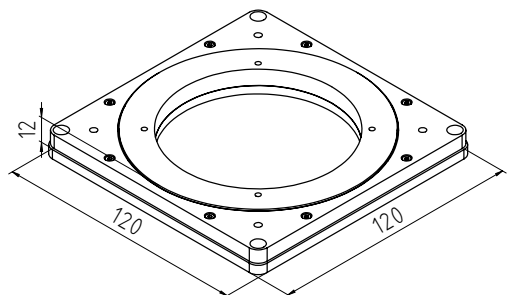
SR-9219 (C) matches modular systems based on CLS-92 stages and features a large aperture and a robust high-precision ceramic bearing.



Detailed technical drawings and 3D models can be found on our website.



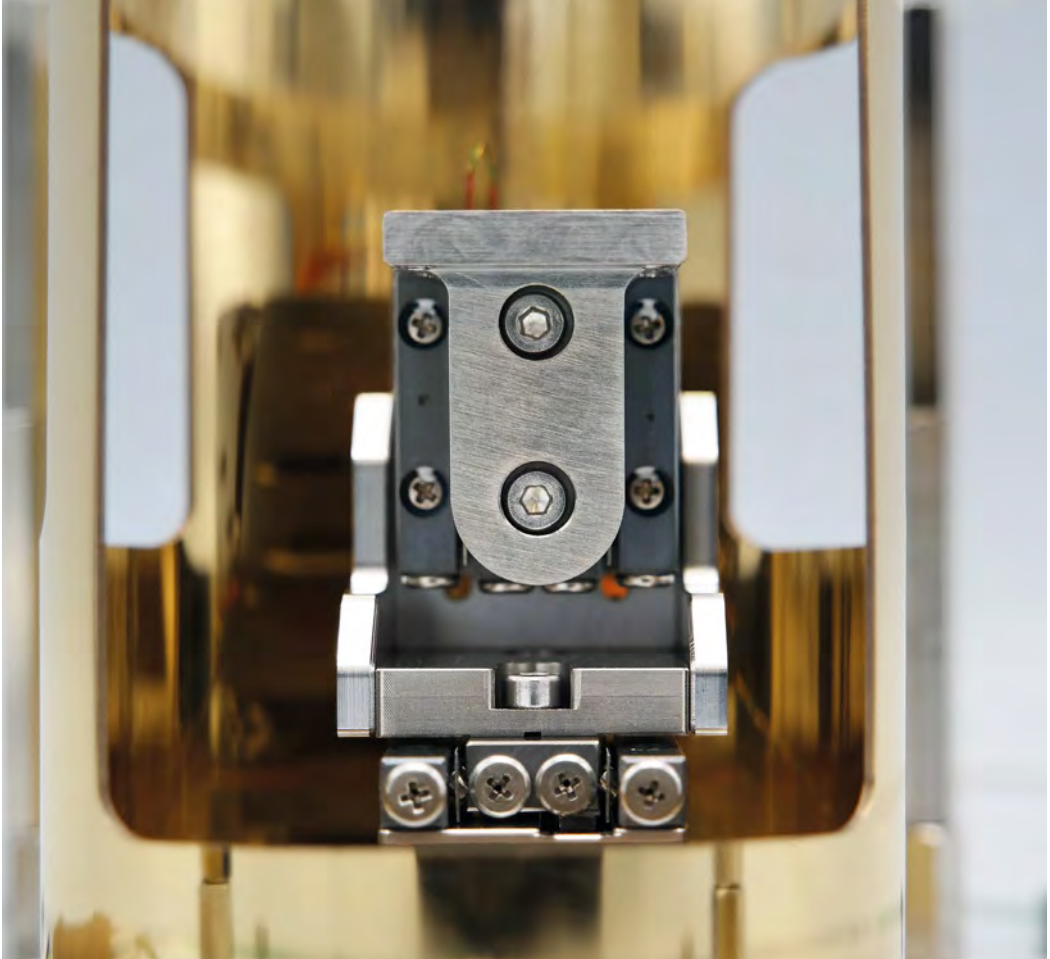
SR-12012 combines highest precision with a large 82 mm aperture for specialized applications.



Detailed technical drawings and 3D models can be found on our website.

SMARSLIDE – Cryogenic Stages and Systems

Introduction



Optimized for confined spaces: A three axes cryo positioning system inside of cryostat's heat shield.

Many applications in industrial and fundamental research require cryogenic temperatures. Additionally, in many cases it is not only necessary to cool the samples but also to mechanically manipulate them precisely within the cryostat. SmarAct has developed **SMARSLIDE** stages with low-heat profiles and ultra-high vacuum compatibility, which allow sample manipulation in temperatures down to the mK regime. Additionally, they can be used up to 330K and can be baked out just like the regular UHV systems. Non-magnetic versions are available as well.

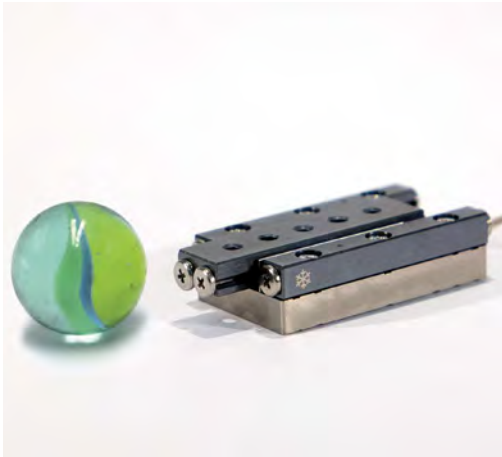
Cryogenic compatibility is achieved by carefully selecting materials with matching thermal coefficients for stages and systems. Resistive cabling (based on phosphor bronze) is optionally available

to reduce the heat load on the positioning stages. Thermal management solutions such as cooling braids can be integrated upon request. Multi-axis cryo-compatible stages are designed as compact as possible in order to fit the tight space constraints that cryostats confer on the design.

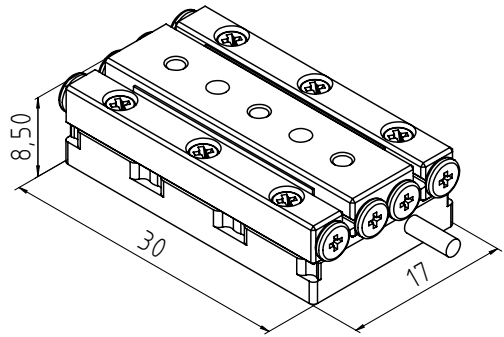
For repeatable high precision positioning under cryogenic conditions, SmarAct has developed cryogenic positioning stages with integrated interferometric sensors featuring unmatched closed-loop positioning performance with resolutions below 0.5 nm and unidirectional repeatability of 5 nm over a travel range of 1 mm and ± 25 nm over a travel range of up to 49 mm. This precision allows a whole range of new applications in the fields of quantum computing and material science.

SMARSLIDE – Cryogenic Stages and Systems

Cryogenic Linear Stages



In comparison to standard SLC series stages, the bases of linear cryo stages are made of titanium.



Detailed technical drawings and 3D models can be found on our website.

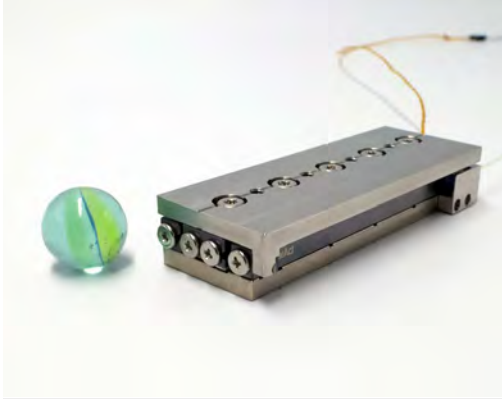
Cryogenic linear stages are specialized versions of SLC stages and completely retain the compact design of the room temperature versions. Therefore, they are ideally suited for limited spaces, typically found in heat shields of cryostats. Materials are

selected to match the required thermal properties and prevent mechanical stress during cooling and heating cycles. This ensures long lifetime under cryogenic and ultra-high vacuum conditions.

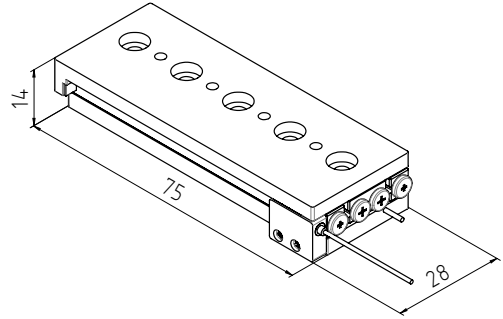
		SLC-1720	SLC-1730	SLC-1740	SLC-1750	SLC-1760	SLC-2430	SLC-2445	SLC-2460
Mechanical	Travel [mm]	6	21	26	31	41	16	29	35
	Blocking Force [N]	≥ 2							
	Max. Normal Force [N]	20	30						
	Max. Lift Force [N]	≥ 1							
	Dimensions [mm] L x W x H	22 x 17 x 8.5	30 x 17 x 8.5	40 x 17 x 8.5	50 x 17 x 8.5	60 x 17 x 8.5	30 x 24 x 10.5	45 x 24 x 10.5	60 x 24 x 10.5
	Weight [g]	20	30	40	50	60	60	80	110
Open-Loop	Velocity [mm/s]	up to 20							
	Resolution [nm]	< 1							
Vacuum Option		HV (10 ⁻⁶ mbar); UHV (10 ⁻¹¹ mbar)							
Non-Magnetic Option		Yes (-NM)							

SMARSLIDE – Cryogenic Stages and Systems

Closed-Loop Cryogenic Stages



SLC-2475-F stage for highest positioning accuracy under cryogenic conditions.

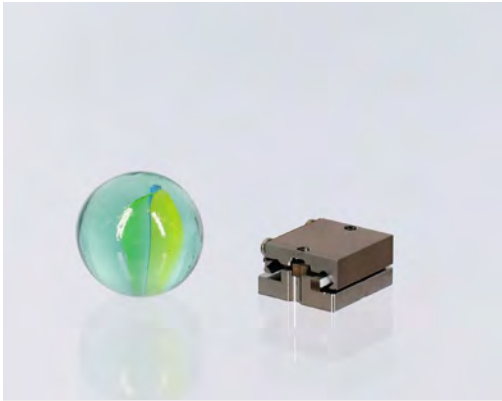


Detailed technical drawings and 3D models can be found on our website.

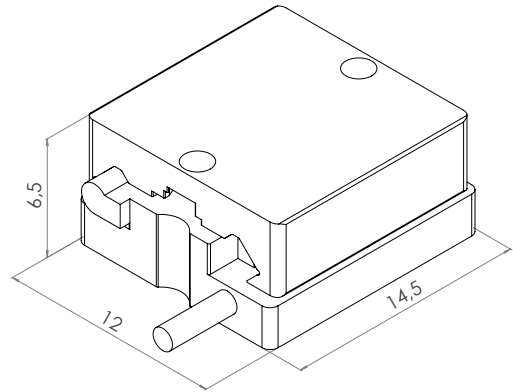
For cryogenic applications where highest precision and thermal stability are essential for successful operation, SMARSLIDE has developed cryogenic positioning stages featuring unmatched closed-loop positioning performance, which makes them ideally suited, for example, in the field of fundamental research including 2D materials science or for cryogenic applications such as low-temperature quantum technologies.

		SLC-2430-F	SLC-2445-F	SLC-2460-F	SLC-2475-F
Mechanical	Travel [mm]	16	29	35	49
	Scan Range [µm]	~ 1 @ 4 K; 5 @ 300 K			
	Blocking Force [N]	≥ 2			
	Max. Normal Force [N]	30			
	Max. Lift Force [N]	≥ 1			
	Dimensions [mm] L x W x H	30 x 28 x 14	45 x 28 x 14	60 x 28 x 14	75 x 28 x 14
	Weight [g]	60	80	110	137.5
Open-Loop	Velocity [mm/s]	> 1 @ 4K; > 20 @ 300K			
	Open-Loop Resolution [nm]	MCS2: < 1			
Closed-Loop	Sensor Resolution [nm]	MCS2: < 0.5 (P)			
	Uni-Directional Repeatability [nm]*	MCS2: ± 25 (P)			
Vacuum Option		HV (10 ⁻⁶ mbar); UHV (10 ⁻¹¹ mbar)			
Non-Magnetic Option		Yes			

* Measured 10 mm above the top surface of the slide and along the line of symmetry. Measured over the entire travel range. An improvement can be expected for shorter travel ranges.



SLT-1213 is a miniature non-magnetic cryogenic linear stage.



Detailed technical drawings and 3D models can be found on our website.

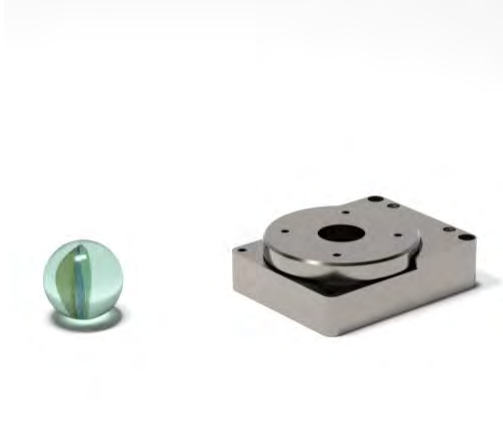
Cryo-compatible SLT stages are very small and lightweight. They can easily be assembled into XY positioning systems.

		SLT-1213
Mechanical	Travel [mm]	5
	Blocking Force (N)	≥ 1
	Max. Normal Force [N]	1
	Max. Lift Force [N]	0.35
	Dimensions [mm] L x W x H	13 x 12 x 6,5
Open-Loop	Velocity [mm/s]	$> 1 @ 4K; > 5 @ 300K$
	Open-Loop Resolution [nm]	MCS2: < 1 (H)CU: < 50
Material Option		Titan base (-TI)
Vacuum Option		HV (10^{-6} mbar); UHV (10^{-11} mbar)

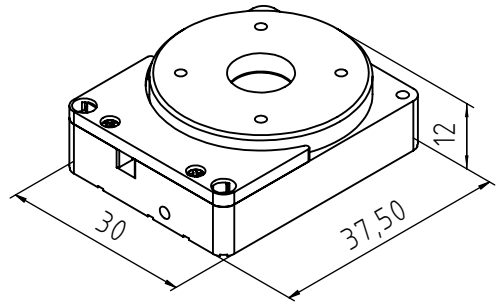
SMARSLIDE – Cryogenic Stages and Systems

Cryogenic Rotation Stage

SmarAct offers cryogenic rotation stages that perfectly complement the linear stages to form sophisticated sample manipulators for cryogenic experiments. The SRT-2006 fits systems comprising stages from the SLC-17xx-CR line, whereas the SR-2812-CR is perfectly suited for systems made from the SLC-24xx-CR line.



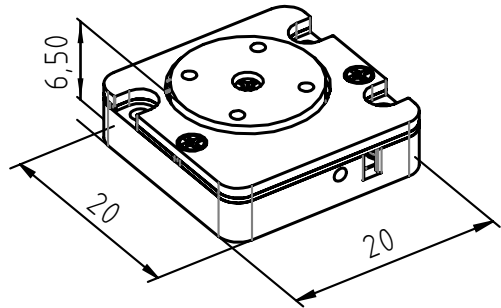
SR-2812-CR cryogenic rotation stage.



Detailed technical drawings and 3D models can be found on our website.



SRT-2006 cryogenic rotation stage mounted on top of a three-axis cryo positioning system.



Detailed technical drawings and 3D models can be found on our website.

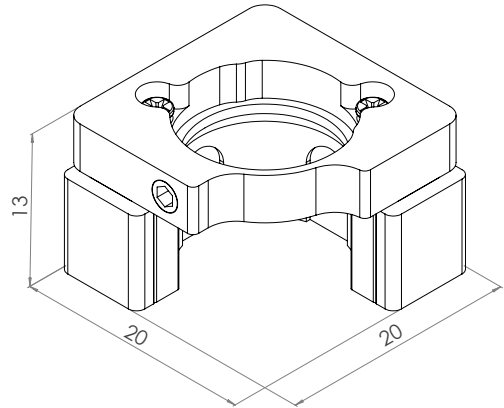
	SRT-2006	SR-2812-CR	
Mechanical	Blocking Torque [Ncm]	0.3	≥ 1
	Max. Normal Force [N]	0.5	2
	Dimensions [mm] L x W x H	20 x 20 x 6.5	37.5 x 30 x 12
	Travel [°]	∞	∞
Open-Loop	Resolution [μ°]	< 10	> 1
	Angular Velocity [°/s]	> 10	≥ 5

SMARSLIDE – Cryogenic Stages and Systems

Cryogenic Tip-Tilt-Mirror Mount



The STT-12.7-CR is tip tilt mirror mount for low-temperature applications.



Detailed technical drawings and 3D models can be found on our website.

The STT-12.7-CR belongs to SmarAct's optomechanic line and is a high-resolution tip-tilt mount for the manipulation of optical components in cryogenic applications.

		STT-12.7-CR
Mechanical	Dimensions [mm]	20 x 20 x 13
	Weight [g]	20
	Mirror Diameter [inch]	0.5
	Tip Angles [°]	± 2
	Tilt Angles [°]	± 2
Open Loop	Angular Velocity [°/s]	15
Material Options		Titanium base (-TI)
Cryogenic Options		Yes
Vacuum Option		HV (10 ⁻⁶ mbar); UHV (10 ⁻¹¹ mbar)
Non-Magnetic Option		Yes (-NM)

SMARSLIDE – Ultra High Vacuum Stages and Systems

Environment-Specific Stages

Ultra High Vacuum Piezo Stages

SMARSLIDE stages and systems are not only perfectly suited for applications under atmospheric conditions, but in some cases also for more extreme environments like high vacuum (HV, 10^{-6} mbar) and ultra-high vacuum (UHV, 10^{-11} mbar). Most of the stages presented in this catalog are available in versions specifically prepared for operation under vacuum conditions. UHV versions are bakeable at up to 150 °C and are available with two different cable types:

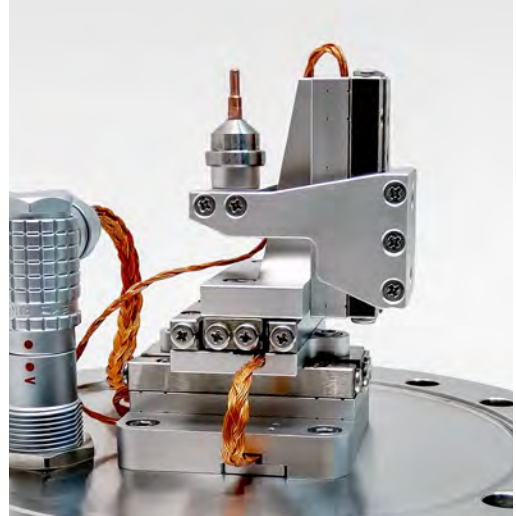
- The cost efficient version utilizes Teflon® insulated wires.
- The Kapton® insulated version is a fluorine free solution.

Since SmarAct is a full solution provider, HV and UHV positioning systems are supplied with matching electrical feedthroughs. As standard, SmarAct uses:

- HV as bulkhead LEMO® feedthroughs sealed with O-rings.
- Tightly welded designs for use in UHV.

Feel free to contact us at any time. We are happy to discuss your specific requirements with you.

For vacuum compatible stages of the SLC-17 and SLC-24 series that require post-installation baking, we recommend opting for the U-shaped base to increase the overall stiffness of the stage.



HV compatible positioning system with Kapton® insulated cabling and LEMO multipin feedthrough on DN100CF flange.

Please note that the U-shaped base has the usual mounting hole pattern, but increases the width of the stage itself by 6 mm. This changes the width of an SLC-17 stage to 23 mm and the width of an SLC-24 stage to 30 mm (see pages 14 and 16 for details). Omitting the U-shaped base option is only advisable if compactness is the top requirement.

	Atmospheric Conditions	High Vacuum (HV)	Ultra-High Vacuum (UHV)	Ultra-High Vacuum (UHVT)
Pressure		Down to 10^{-6} mbar	Down to 10^{-11} mbar	
Wiring	Teflon® - insulated stranded wires with braided shield and Teflon® sheath	Teflon® - insulated stranded wires with braided shield	Kapton® - insulated insulated stranded wires	Teflon® - insulated stranded wires with braided shield
Grease	Standard grease	HV compatible grease	Grease-free	
Sensor Options	S, L, I	S	S	
T _{Bake-Out}	--	Up to 130°C upon request	Recommended 130°C (max. 150° C)	
Vacuum Feedthrough	--	LEMO® feedthroughs • O-ring tightened by a screw nut • Flanges available upon request	LEMO® compatible steel multipin or D-SUB15 PEEK feedthroughs welded into vacuum flange • DN40CF or DN63CF flange, other sizes upon request	

SMARSLIDE – Non-magnetic Stages and Systems

Environment-Specific Stages

Non-Magnetic Stages and Systems

For applications, in magnetic fields or in any other setups where non-magnetic materials are required, SmarAct offers completely non-magnetic SMARSLIDE stages and systems. Typical materials for these stages are titanium, ceramics, copper wires with Teflon® or Kapton® insulation and copper beryllium.

Non-magnetic stages of the SLC-17 and SLC-24 series include ceramic guideways. We recommend that you also opt for the U-shaped base to increase the overall stiffness of the stage. It has the usual mounting hole pattern, but is wider than the standard stages. Therefore, the stages with U-shaped bases of the SLC-17 series are 23 mm wide and those of the SLC-24 series are 30 mm wide. Dispensing with the U-shaped base plate is only advisable if compactness is most important.



Ultra-compact non-magnetic positioning system with ceramic guideways.




SMARPODs are optionally available in non-magnetic versions for use in high magnetic fields or for ion or electron spectroscopy experiments.



SMARFLEX

Nanoprecision Flexure Stages

 SMARFLEX nanopositioning scanner stages use the advantages of piezo-driven mechanical flexures to realize highly precise positioning tasks up to several 100 μm .

High Resolution

Integrated position sensing provides closed-loop positioning with sub-nm resolution.

Highly Dynamic

Because of the small mass to driving force ratio, a highly dynamic motion can be realized.

Friction-Free Motion

Because flexures are free of friction, no maintenance of wear parts is required. Furthermore, this leads to motion with very high repeatability.

Minimized Parasitic Motion

FEM-optimized flexures precisely guide the motion and reduce motion orthogonal to the intended direction.

Vibration-Free Motion

The motion principle is based on lever amplified piezo actuators making a continuous and vibration free motion possible.

Compact and Lightweight

Flexures allow for a very compact design and are most often manufactured from a single piece of material. This reduces their weight and footprint.

Vacuum Compatibility

Because flexures are free of friction, no grease is required and only ultra-high vacuum compatible parts can be used.

Non-Magnetic Materials

Flexure stages are available in non-magnetic material versions.

Compatibility

Control unit and the mechanical interfaces are compatible with **SMARSLIDE** and **SMARSHIFT** technologies making it possible to combine all advantages from different driving technologies.

Customizability

SMARFLEX positioners are customizable to a large degree. If required, also further performance analysis of custom-made positioners can be carried out in the **SMARFLEX** laboratory.

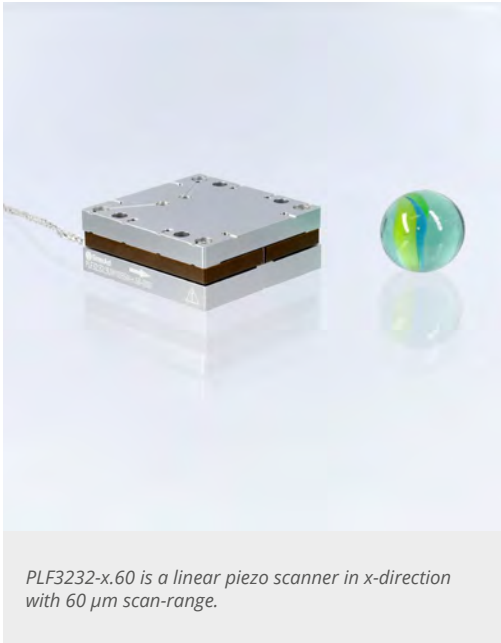


For scanning applications such as AFM, SmarAct offers scanning stages with maximum scanning speed and minimum scanning error. Also in the field of optical microscopy, focal points can be set accurately, mirrors can be tilted very precisely or optical fibers can be coupled. The PLF stages offer high-precision piezo scanners with different scan directions. They can easily be combined to form multi-axis scanning systems.

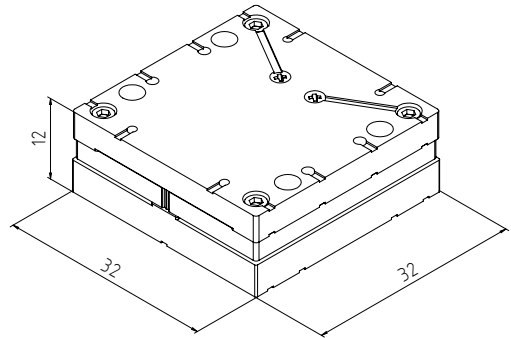
		PLF3232-x.60	PLF3232-z.60	PLF5252-x.200	PLF3232-xy.60
Mechanical	Scan Range [μm]	> 60		> 200	> 60
	Stiffness [$\text{N}/\mu\text{m}$] *	0.5	0.3	0.1	0.5
	Scantilt [μrad] **	± 3.5	± 50	± 5	± 3.5
	Max. Normal Force [N]	5.0			
	Weight [g]	30	30	90	45
	Dimensions [mm], (L x W x H)	32 x 32 x 12	32 x 32 x 15	52 x 52 x 15	32 x 32 x 20
Material	Base Material	Titanium(-Ti) / Aluminum base (-Al)			
Open-Loop	Open-Loop Resolution [nm]	MCS2: < 1			
Closed-Loop	Sensor Resolution [nm]	MCS2: < 1 (S)			
Vacuum Options		HV (10^{-6} mbar)			
Non-Magnetic Option		Yes (- NM)			

* Tolerance $\pm 20\%$

** Typical value. Equal for both rotational axes orthogonal to direction of motion. With respect to center position.



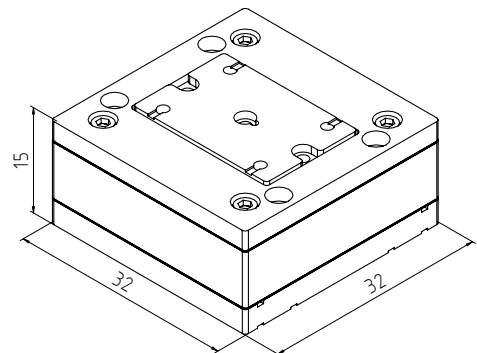
PLF3232-x.60 is a linear piezo scanner in x-direction with 60 μm scan-range.



Detailed technical drawings and 3D models can be found on our website.



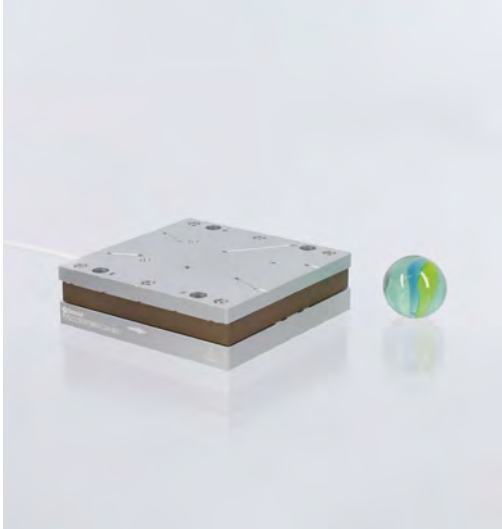
PLF3232-z.60 is a linear piezo scanner in z-direction with 60 μm scan-range.



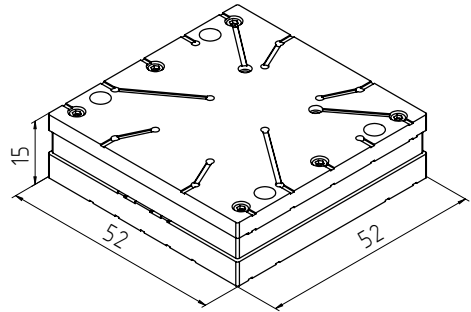
Detailed technical drawings and 3D models can be found on our website.

Flexure Stages

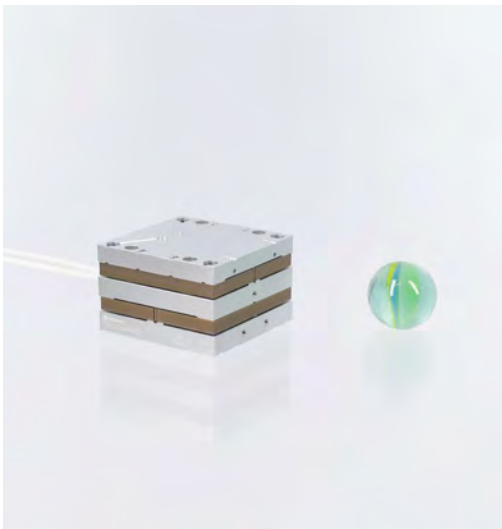
PLF Series



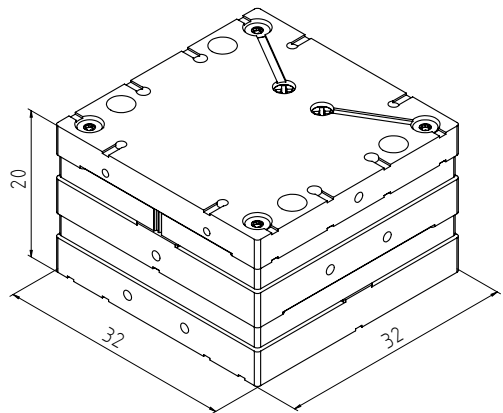
PLF5252-x.200 is a linear piezo scanner in x-direction with 200 μm scan-range.



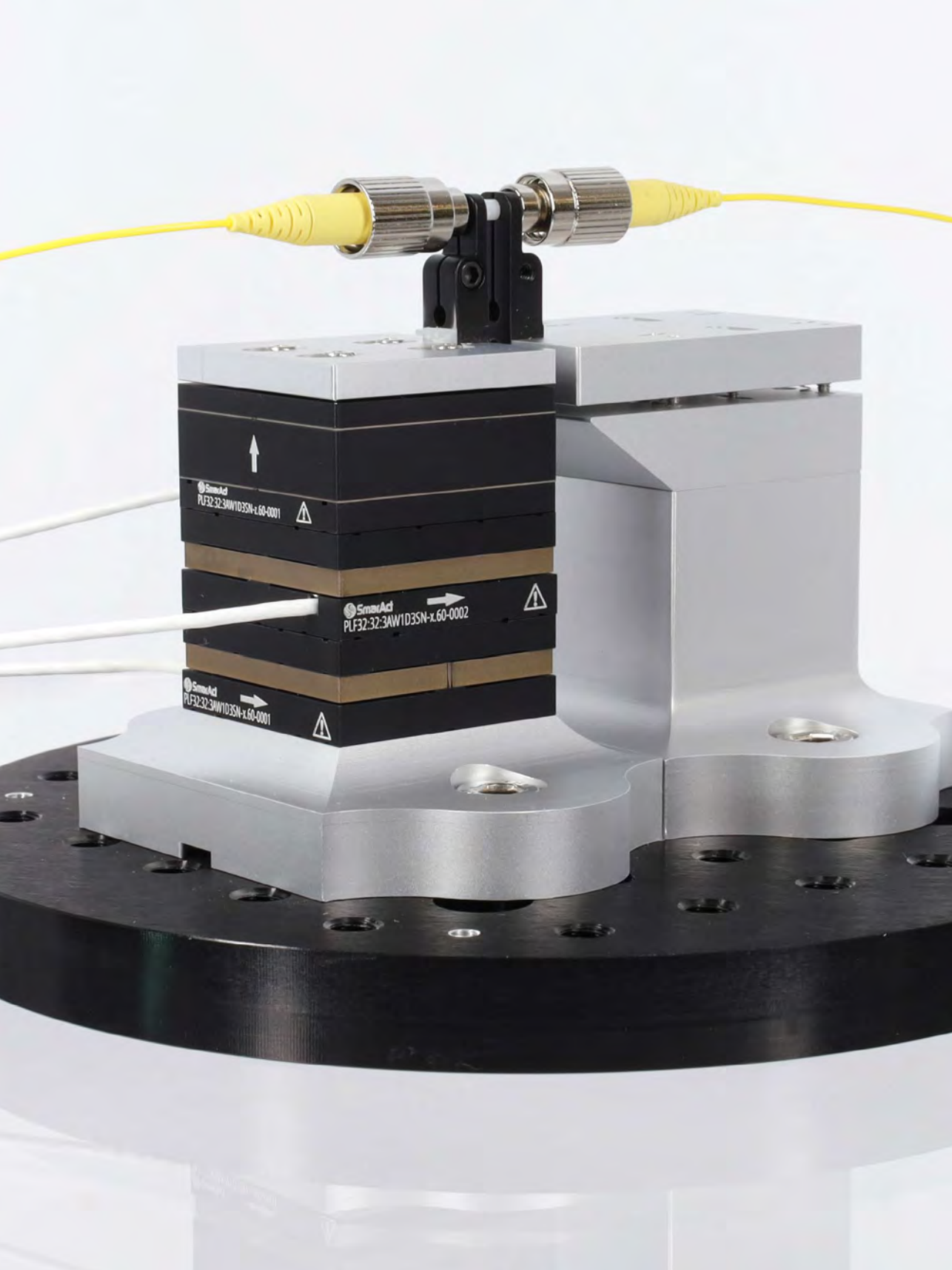
Detailed technical drawings and 3D models can be found on our website.



PLF3232-xy.60 is a linear piezo scanner with two degrees of freedom and a scan range of 60 μm in the X and Y direction.




Detailed technical drawings and 3D models can be found on our website.





SMARSHIFT – High Precision Electromagnetic Direct Drives

 SMARSHIFT stages feature electromagnetic motors for industrial applications, laboratory automation and compact positioning solutions where high speed, force and nanometer-precise motion must be paired with high duty cycle and durability. The electromagnetic drives enable speeds beyond 1 m/s. In addition, they are durable and virtually maintenance-free. SMARSHIFT positioning stages are designed to be as compact as possible, as well as to be mechanically intercompatible with SmarActs SMARSLIDE positioning systems. This compatibility allows not only the use of the modular system's connecting elements but also side-by-side use with piezo-driven stages in multi-dimensional positioning systems.

Compact Design

SMARSHIFT stages tackle the limits of the trade-off between force and volume. The stages feature both compact size and high force.

Lifetime

Electromagnetic direct drives exhibit reduced wear compared to inertia drives. Following this, SMARSHIFT stages stand out with increased mileage, lifetime and duty cycle.

Customization

Due to the in-house development and manufacturing of all core components, SMARSHIFT stages and positioning systems can be adapted to your requirements within short time periods.

Dynamic Performance

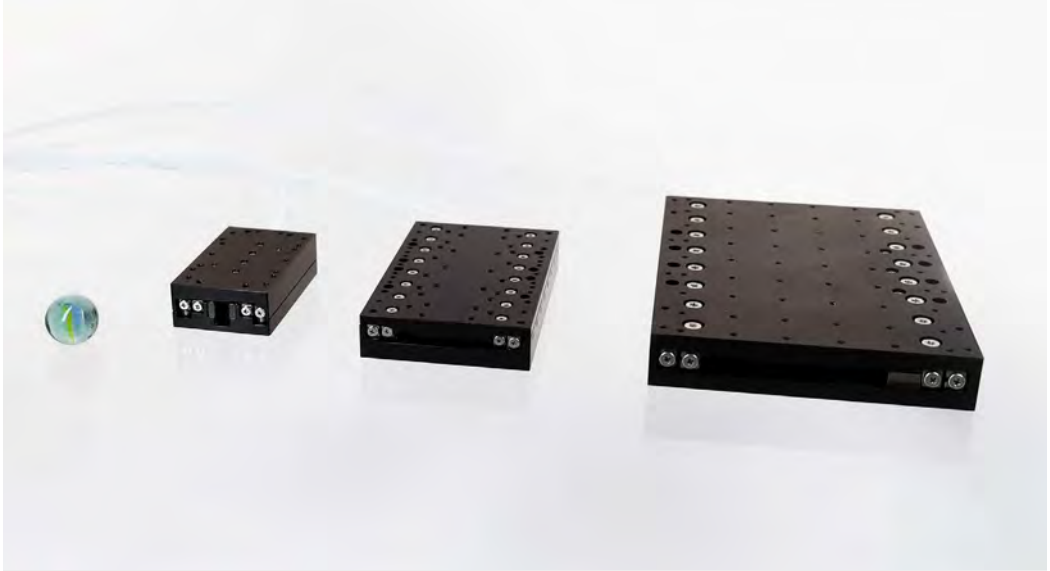
SMARSHIFT stages provide increased force and allow for high accelerations and velocities respectively. They are therefore ideal for applications that require high dynamic performance.

Long Travel Range

The travel range of moving coil stages – such as the MLL series – are only limited to the variable magnet array length. Convenient cable management solutions empower your long travel application.

SMARSHIFT – Electromagnetic Linear Stages

MLS Overview



Electromagnetic linear stages for industrial applications, lab automation and compact positioning solutions.

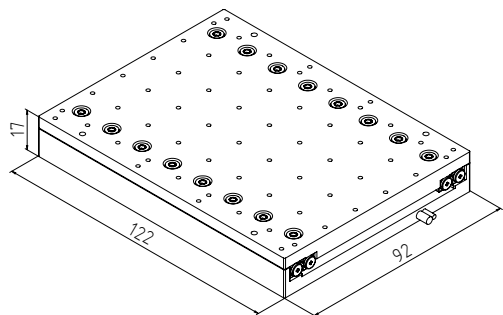
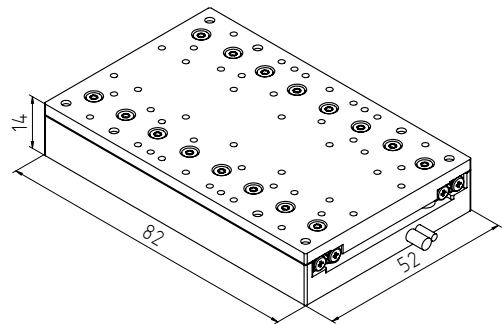
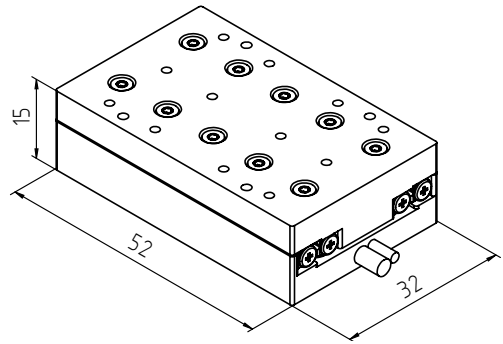
	MLS-3252	MLS-5282	MLS-92122	
Mechanical	Travel [mm]	25	38	65
	Continuous Force [N]	1.0	2.0	7.5
	Peak Force [N]	2.5	5.0	22.0
	Max. Normal Force [N]	10	20	50
	Moved Mass (Unloaded) [g]	40	100	400
	Weight [g]	80	200	640
	Dimensions [mm], L x W x H	52 x 32 x 15	82 x 52 x 14	122 x 92 x 17
	Mechanical Brake	No		Optional
	Weight Compensation [N]	Up to 2.2	Up to 15	Up to 30
Material	Aluminum, black anodized			
Closed-Loop	Velocity [mm/s]*	350	750	900
	Max. Acceleration (no load) [m/s ²]	50	45	
	In-Position Stability [nm]	3		
	Uni-Directional Repeatability [nm] **	MCS2: ±40		

* Reached at 50% of travel range, without load

** Measured above the top surface of the slide and along the line of symmetry. Measured over the entire travel range. An improvement can be expected for shorter ranges.

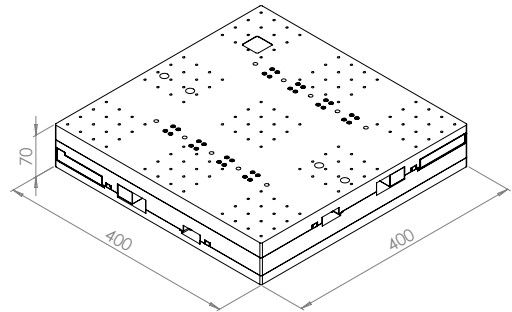
SMARSHIFT – Electromagnetic Linear Stages

MLS Series



SMARSHIFT – Electromagnetic Linear Stages

MLL Series



Detailed technical drawings and 3D models can be found on our website.

The MLL-400 is an electromagnetic direct drive with two travel options. The first one offers a large travel range of up to 300 mm. The second one features a reduced travel range of 200 mm for increased precision.

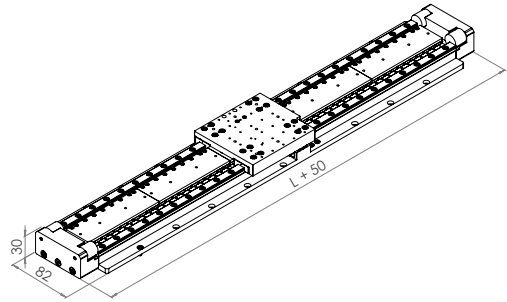
It can be used as XY positioning system or as basis for an electromagnetic TRIPOD. See page 89 for details.

The MLL-400 can be mounted on a standard optical table with a 25 mm x 25 mm M6 mounting hole grid.

		MLL-400	
Mechanical	Travel [mm]	200	300
	Continuous Force [N]	6	
	Peak Force [N]	18	
	Max. Normal Force [N]	50	
	Moved Mass (Unloaded) [g]	Lower axis: 13000 Upper axis: 6000	
	Weight [g]	21000	
	Dimensions [mm], L x W x H	400 x 400 x 70	
Material	Base Material		Aluminum black anodized
Closed-Loop	Velocity [mm/s]	Lower axis: max. 200 Upper axis: max. 200	
	Uni-Directional Repeatability [nm]	Typical < ±100	Typical < ±150
	Max. Acceleration (no load) [m/s ²]	Lower axis: 1 Upper axis: 2.5	

SMARSHIFT – Electromagnetic Long Travel Stages

MLL Series



Detailed technical drawings and 3D models can be found on our website.

The MLL-82 is an electromagnetic direct drive with variable travel ranges according to your individual requirements. The positioners are available with lengths increments of 100 mm.

It can be easily combined with other stages of the MLS-series.

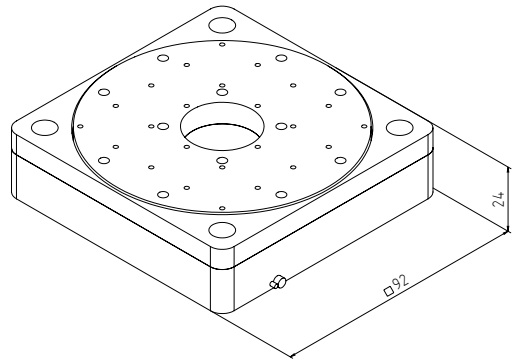
The picture above shows a MLL-82500 with more than 400 mm travel and energy chain for cable routing.

		MLL-82200	MLL-82300	MLL-82400	MLL-82500
Mechanical	Travel [mm]	105	205	305	405
	Continuous Force [N]	5			
	Peak Force [N]	15			
	Max. Normal Force [N]	50			
	Moved Mass (Unloaded) [g]	400			
	Dimensions [mm], L x W x H	250 x 82 x 30	350 x 82 x 30	450 x 82 x 30	550 x 82 x 30
Material	Base Material Aluminum black anodized				
Closed-Loop	Velocity [mm/s]	1100	1600	1900	2000
	Uni-Directional Repeatability [nm]:	Typical < ±45			
	Max. Acceleration (no load) [m/s ²]	30 m/s ²			

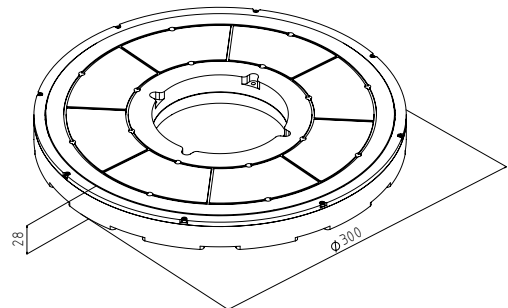
SMARSHIFT – Electromagnetic Rotation Stages

MR Series

Rotational stages of the **SMARSHIFT** MR series allow for high loads and 24/7 operation – with uncompromising precision and minimal space requirement. Paired with fast rotation and lowest settling times, they are the perfect match for your demanding application.



Detailed technical drawings and 3D models can be found on our website.



Detailed technical drawings and 3D models can be found on our website.

SMARSHIFT – Electromagnetic Rotation Stages

MR Series

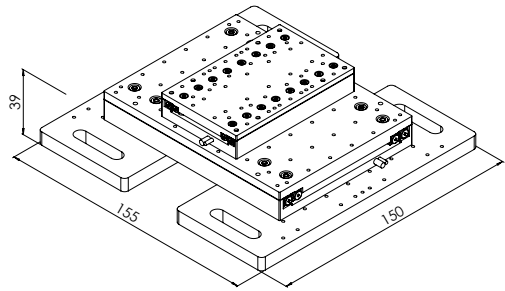


Rotational electromagnetic direct drives for applications that demand high precision, high torque and long lifetime on a limited space.

	MR-9224	MR-30028	
Mechanical	Travel [°]	∞	
	Peak Torque [Ncm]	30	500
	Continuous Torque [Ncm]	10	300
	Max. Normal Force [N]	50	1000
	Dimensions [mm], L x W x H	92 x 92 x 24	300 x 300 x 28
	Weight [g]	650	5000
	Inertia [kg m ²]	0.00027	0.029
	Aperture [mm]	25	110
Closed-Loop	Angular Velocity [°/s]	3000	540
	Angular Acceleration [°/s ²]	1800	5400
	180° Rotation Time [ms]	250	500
	Unidirectional Repeatability [μ°]	40	
	Sensor Resolution [μ°]	< 2	< 1
Material	Aluminum black anodized		

SMARSHIFT – Typical Electromagnetic Systems

2 DoF Positioning Systems



Detailed technical drawings and 3D models can be found on our website.

Based on two MLS stages, XY systems can be built directly without adapter plates. The modularity of the MLS series allows combinations of different MLS sizes to be assembled to cover a wide range of applications.

Compatibility with the SmarAct modular system makes it easy to upgrade.

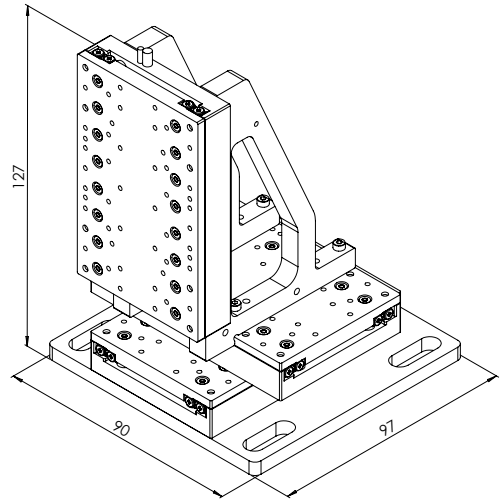
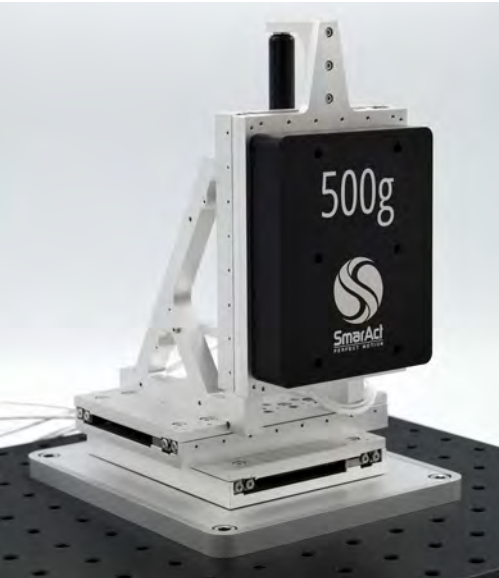
The picture above shows an XY-MLS system consisting of the X-axis MLS-92122 and an attached Y-axis MLS-5282.

A complex multi-axis system with **SMARSHIFT** stages is the electromagnetic **TRIPOD**. See page 89 for details.

		XY-MLS-92122	XY-MLS-5282	XY-MLS-3252	XY-X-MLS-92122-Y-MLS-5282	XYZ-X-MLS-5282-Y-MLS-3252
	Degrees of Freedom	2				
	Linear Stage X	MLS-92122	MLS-5282	MLS-3252	MLS-92122	MLS-5282
	Travel X [mm]	65	38	25	65	38
	Linear Stage Y	MLS-92122	MLS-5282	MLS-3252	MLS-5282	MLS-3252
	Travel Y [mm]	65	38	25	38	25
	Payload [N]	43	18	9	20	10
Breadboard Mount	Dimensions [mm] L x W x H	155 x 150 x 42	90 x 90 x 33	65 x 65 x 35	155 x 150 x 39	90 x 90 x 34
	Height of Working Platform above Ground [mm]	42	33	35	39	34
Direct Mount	Dimensions [mm] L x W x H	122 x 122 x 34	82 x 82 x 28	52 x 52 x 30	122 x 82 x 31	82 x 52 x 29
	Height of Working Platform above Ground [mm]	34	28	30	31	29

SMARSHIFT – Typical Electromagnetic Systems

3 DoF Positioning Systems



Detailed technical drawings and 3D models can be found on our website.

Different sizes of MLS stages can be combined to create a variety of XYZ systems. Thanks to their compatibility with the SmarAct modular system, they can be easily upgraded. Suitable weight compensations are available. The XYZ-MLS-92.122 shown in the picture above has weight compensation in the form of a gas spring for heavy payloads.

		XYZ-MLS-92122	XYZ-MLS-5282	XYZ-MLS-3252
Degrees of Freedom		3		
Linear Stage X		MLS-92122	MLS-5282	MLS-3252
Travel X [mm]		65	38	25
Linear Stage Y		MLS-92122	MLS-5282	MLS-3252
Travel Y [mm]		65	38	25
Linear Stage Z		MLS-92122	MLS-5282	MLS-3252
Travel Z [mm]		65	38	25
Payload [N]*		36	16	8
Breadboard Mount	Dimensions [mm]**	155 x	97 x	75.5 x
	L x W x H	150 x	90 x	65 x
		181	127	92
Direct Mount	Dimensions [mm]**	132 x	89 x	62.5 x
	L x W x H	122 x	82 x	52 x
		175	122	87

* Max. values. Achievable with weight compensation.

** Without weight compensation.

*A hexapod-like SMARPOD positioning system
with six degrees of freedom utilizing SLC series
stages and a long travel CLL linear stage.
See page 77 for details.*



SMARBOTIC High Precision Positioning Systems and Robots

The ongoing miniaturization in many technology areas requires innovative and high-precision tools. **SMARBOTIC** systems enable alignment and manipulation of samples and tools on the nanometer scale in multiple degrees of freedom. **SMARBOTIC** offers a wide range of multi-axis manipulator systems, optimized for different application scenarios in industry and research providing the following advantages:

Versatile and Modular

SMARBOTIC systems combine linear, rotational and goniometric axes in a modular way leading to serial, parallel or hybrid kinematics and allowing for rapid integration into customer setups.

Highly Customizable

In addition to our standard systems, **SMARBOTIC** systems can be tailored to your applications and will be designed by our experts according to your specifications. Benefit from our experience in the development of special systems for many well-known customers.

High Resolution and Closed-Loop Control

SMARBOTIC systems feature a backlash-free mechanical design and closed-loop control that enables nanometer-scale motion performance and high repeatability.

Compact Design

SMARBOTIC systems are designed in the most compact way to realize smallest footprints while providing maximum travel ranges.

Vacuum Compatibility and Non-Magnetic Materials

Most **SMARBOTIC** systems are available as vacuum-capable versions up to 10^{-11} mbar and as non-magnetic versions.

This catalog section provides an overview of possible solutions for multi-dimensional positioning projects. First, we introduce the SmarBotic modular system and pre-defined systems followed by more complex positioning systems. These include the hexapod-like **SMARPOD** series as well as the **TRIPOD** series. As another option, we present the **SMARGON** – a versatile multi-axis positioning system combining serial and parallel kinematic approaches.

SMARBOTIC – Modular System

Introduction

Change is a constant in academic research as well as in industrial manufacturing. Equipment needs to be adaptable in order to address new requirements and to keep investments manageable.

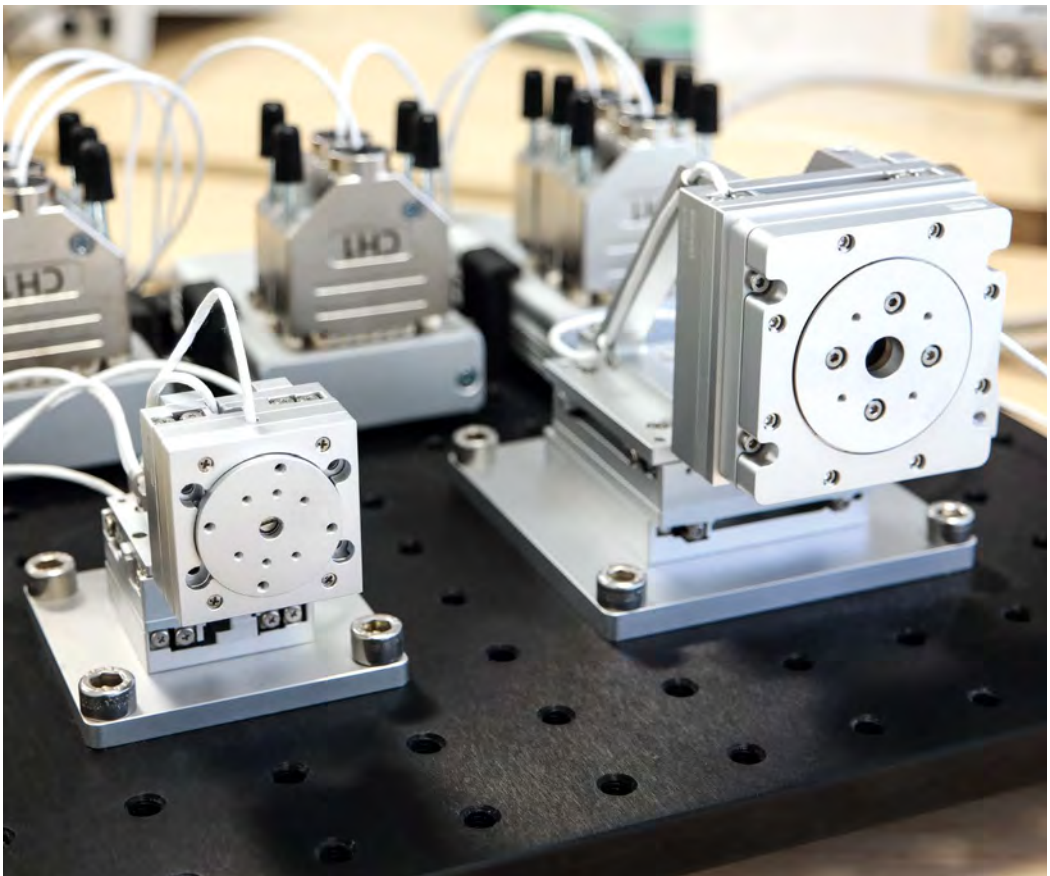
SmarAct's modular system is a product concept which allows customers to adapt, modify and reconfigure even complex multi-axis positioning systems in the field, based on stringent modularity and intercompatibility between linear, rotation and goniometer stages.

It allows the combination of compatible stages of the CLS, SLC, CGO, DLS, MLS, PLF and SR product series to form complex and reconfigurable positioning setups. Standardized angle brackets, adapters and accessories provide the flexibility needed to combine SmarAct's single-axis stages into con-

vertible instruments while guaranteeing the highest precision and quality of the positioning solution thus created.

Due to the high modularity and large number of components and accessories, the SmarAct modular system offers almost endless possibilities to build your very own setup.

The positioning systems presented in the following serve as examples to show the possibilities and on-site reconfigurability of SmarAct's modular system.

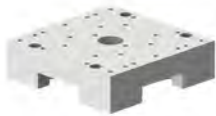


With standardized connection elements, the SmarAct modular system allows to build multi-dimensional positioning systems.

Breadboard Adapters and Base Plates



Several breadboard adapters are available to fix the positioning system onto your existing optical table or breadboard based experimental setup. The product portfolio includes adapters of different sizes and shapes perfectly matching the corresponding linear stages of the SLC and CLS series. The mounting hole pattern of the adapters allows mounting of linear and rotation stages of different sizes while also providing anchoring points for cable management clamps.



Spacer

Spacers have the same outer dimensions as the corresponding linear stages. They can be mounted directly onto breadboard adapters, on top of positioning stages and also on top of each other.



Brackets

Brackets allow vertical mounting of linear, rotation or goniometer stages to other stages or directly onto the breadboard adapters. Several different dimensions are available to allow mounting of SLC and CLS linear stages, SR rotation stages as well as CGO goniometer stages of different sizes.



Adapter Plates and Clamps

Adapter plates and clamps are required when stacking linear stages or when mounting right-angled brackets or rotation stages. The shape of the clamp depends on the length and the mounting hole pattern of the linear stages used. There are clamps for mounting right-angled brackets on linear stages or for mounting two linear stages perpendicular to each other.



Constant Force Springs

Constant force spring assemblies compensate for static loads on stages when used in vertical orientation. Each assembly includes an adapter that attaches to the bracket as the anchor point for the spring and an adapter plate that mounts to the front of the vertical stage.

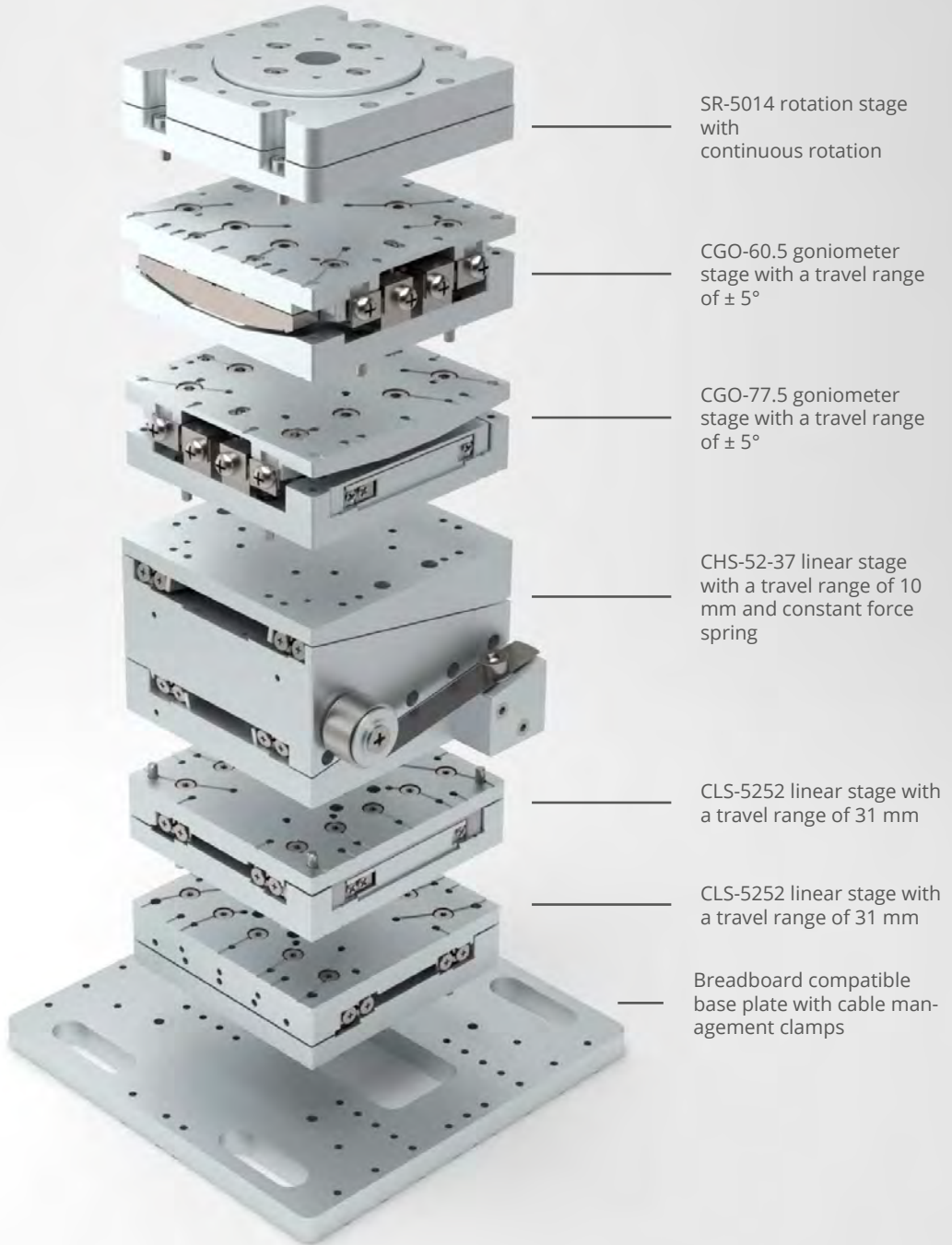


Cable Management

The SmarAct modular system also includes clamps for cable management. Various clamp sizes are available, optimized to securely hold a defined number of cables with different diameters.

SMARBOTIC – Modular System

1st Example: 6D Positioning System



This example shows a versatile setup which is characterized by its simplicity and stiffness.

SMARBOTIC – Modular System

1st Example: 6D Positioning System



An XY system represents a versatile platform: for microassembly setups, as a microscopy stage or simply whenever components or assemblies need to be positioned precisely and reproducibly in two dimensions. It can be used in any orientation.



Adding the CHS-5237 high load stage to the XY system, transforms it into an XYZ platform.



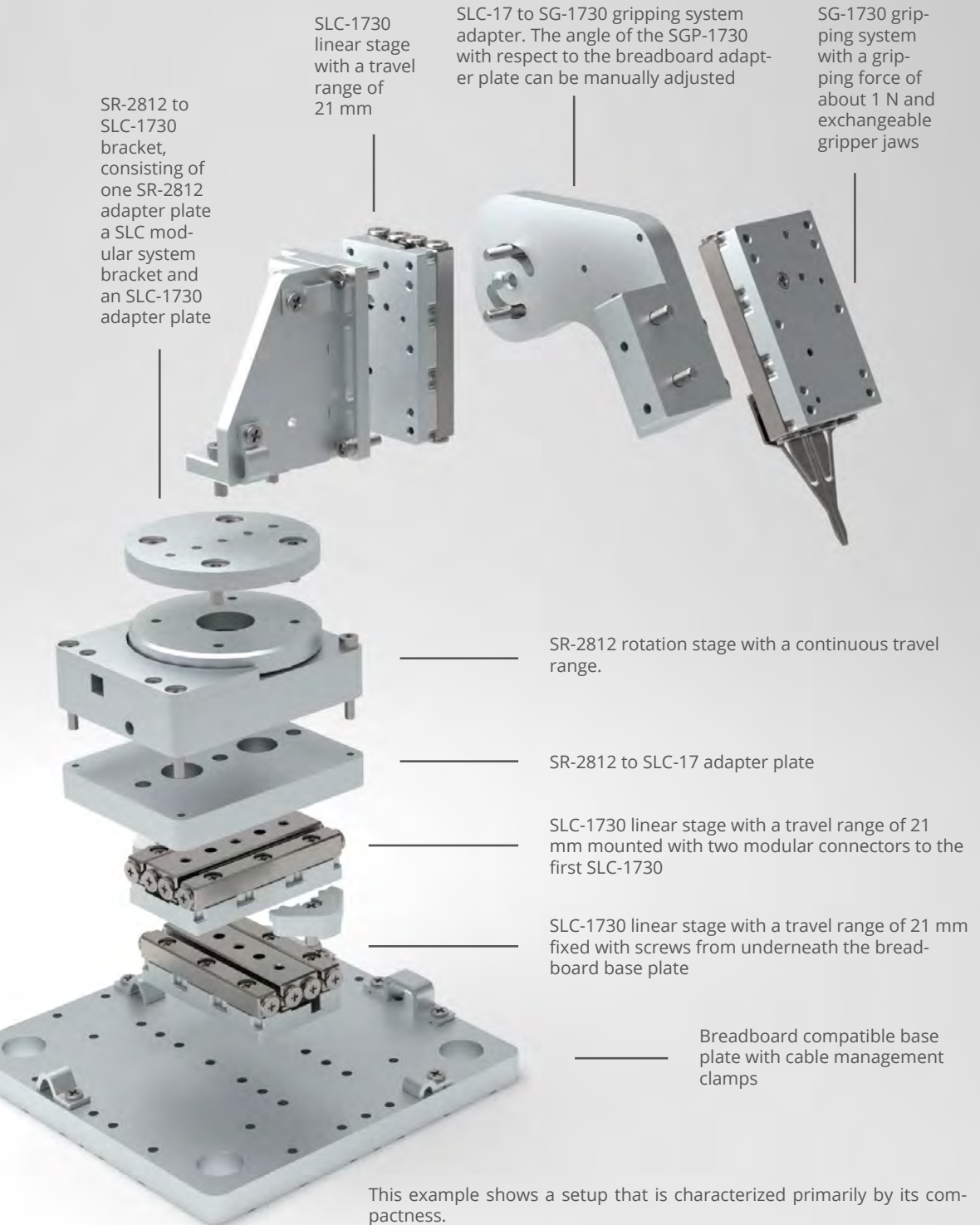
A rotation stage can be mounted directly onto the XYZ platform, adding a rotational degree of freedom to the setup.



When the Eulerian cradle is placed on top of the XYZ platform, the setup allows for accurate positioning of the common pivot point in the XY plane.

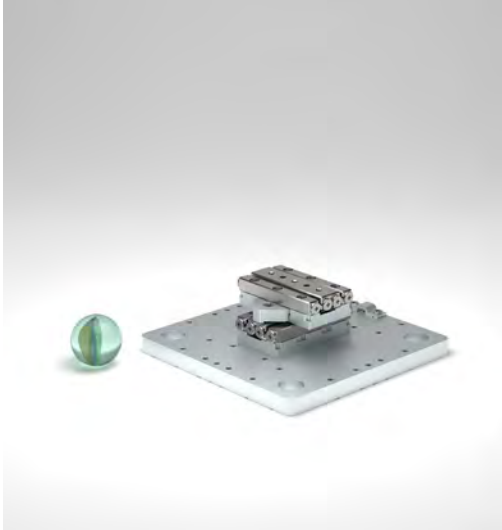
SMARBOTIC – Modular System

2nd Example: 5D Micromanipulation Device

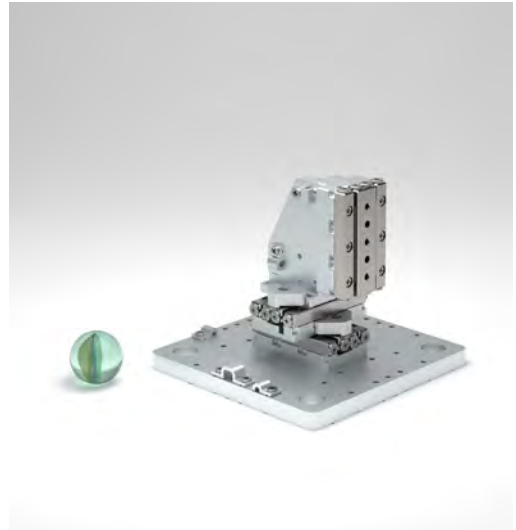


SMARBOTIC – Modular System

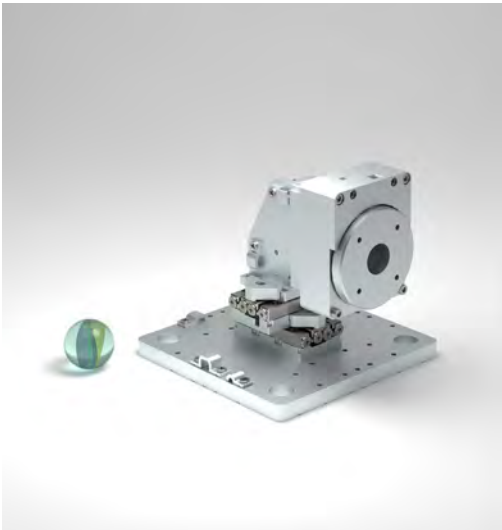
2nd Example: 5D Micromanipulation Device



An XY system represents a versatile platform. SLC linear stages can be easily and securely mounted on top of each other with the help of modular connectors.



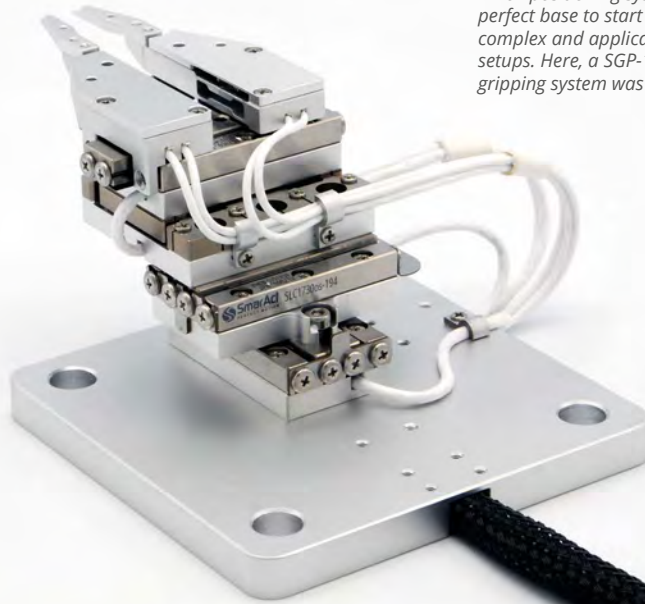
The XYZ arrangement is also a frequently requested configuration, which SmarAct can offer in many variants due to variable lengths of the positioning stages.



An XYZ positioning system can be extended with a rotational degree of freedom by adding an SR-2812 via an SLC-17 adapter plate. The system thus created enables precise positioning of the pivot point.



The SG-1730 gripping system of the example on the left page can also be exchanged for a fourth SLC linear stage, creating a tool platform with a travel range of 21 mm. Pipettes, micro-knives, microinjectors or other mechanical or electrical probes can then be mounted to the platform.



2 DoF positioning systems are the perfect base to start building more complex and application specific setups. Here, a SGP-1730 parallel gripping system was integrated.

SMARBOTIC – Typical Positioning Systems

Within the scope of SmarAct's modular system, fully typical positioning systems are available. These pre-defined positioning systems are customer inspired and present the systems and platforms most commonly requested by our customers.

The systems are very versatile and can be used for a wide range of positioning tasks. In the following, the systems are displayed including a breadboard adapter. All systems are also available without the breadboard adapter if a direct mounting method is preferred.

On the basis of these typical systems, and in combination with customized connection elements and customized stages, very complex serial positioning systems can be realized. Some of them are presented on the following pages.

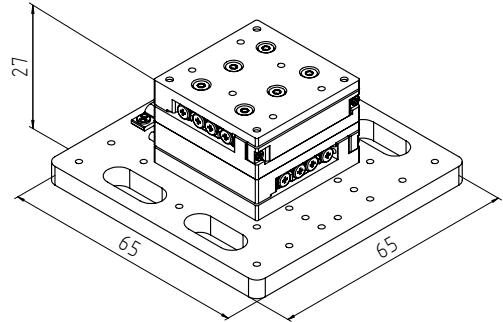
If your application requires a special configuration that is not shown in the following, please do not hesitate to contact our application specialists to discuss your application's requirements.

SMARBOTIC – Typical Positioning Systems

2 DoF Positioning Systems



XY-CLS32:32 is a positioning system with 2 DoF based on CLS-3232 stages.



Detailed technical drawings and 3D models can be found on our website.

2 DoF systems consist of two linear stages of the SLC or CLS series in a XY configuration. Such setups represent most versatile platforms whenever components or substages, like gripping systems, need to be precisely and reproducibly positioned in two dimensions.

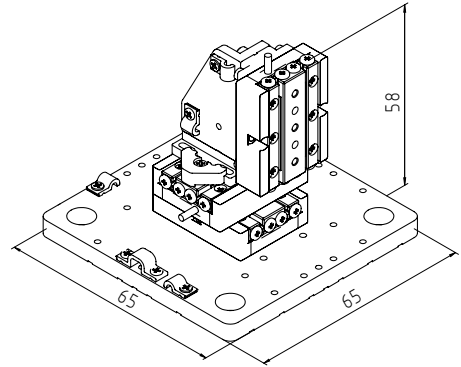
		XY-SLC-17:22	XY-SLC-17:30	XY-SLC-17:80	XY-SLC-24:60	XY-CLS32:32	XY-CLS52:52
Direct Mount	Degrees of Freedom	2					
	Linear Stage X	SLC-1720	SLC-1730	SLC-1780	SLC-2460	CLS-3232	CLS-5252
	Travel X [mm]	12	21	51	35	21	31
	Linear Stage Y	SLC-1720	SLC-1730	SLC-1780	SLC-2460	SLC-3232	SLC-5252
	Travel Y [mm]	12	21	51	35	21	31
	Payload [N]	20		30		20	
	Resolution MCS2 [nm]	1 (S)					
Breadboard Mount	Dimensions [mm] L x W x H	65 x 65 x 24	65 x 65 x 22	80 x 80 x 22	65 x 65 x 26	65 x 65 x 27	90 x 90 x 34
	Height of Working Platform above Ground [mm]	24	22	22	26	27	
Direct Mount	Dimensions [mm] L x W x H	22 x 22 x 19	22 x 32 x 17	80 x 80 x 17	60 x 60 x 21	32 x 32 x 22	52 x 52 x 28
	Height of Working Platform above Ground [mm]	19	17		21	22	

SMARBOTIC – Typical Positioning Systems

3 DoF Positioning Systems



XYZ-SLC23:30 is a positioning system with 3 DoF based on SLC-1730-W stages.



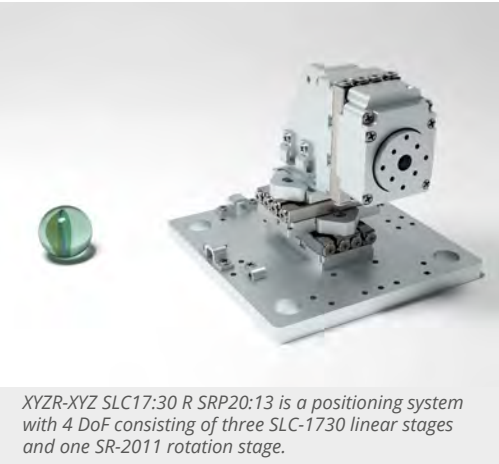
Detailed technical drawings and 3D models can be found on our website.

Systems with three degrees of freedom consist of three linear stages of the SLC or CLS series in an XYZ configuration. Such setups represent standard devices for sample positioning tasks. In optical setups, this three-axis positioning system can be used for the alignment of optical detectors or whenever components or substages, need to be precisely and reproducibly positioned in three dimensions.

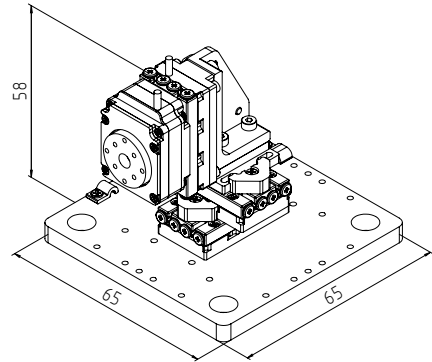
		XYZ-SLC17:30	XYZ-SLC23:30	XYZ-XY SLC17:40 Z SLC17:30	XYZ-XY SLC17:40 Z SLC17:30	XYZ-CLS32:32	XYZ-CLS32:32
Direct Mount	Degrees of Freedom	3	3	3	3	3	3
	Linear Stage X	SLC-1730	SLC-1730-W	SLC-1740	SLC-1740	CLS-3232	CLS-3232
	Travel X [mm]	21	21	26	26	21	21
	Linear Stage Y	SLC-1730	SLC-1730-W	SLC-1740	SLC-1740	CLS-3232	CLS-3232
	Travel Y [mm]	21	21	26	26	21	21
	Linear Stage Z	SLC-1730	SLC-1730-W	SLC-1730	SLC-1730	CLS-3232	CLS-3232
	Travel Z [mm]	21	21	21	21	21	21
	Payload [N]	1.5		1.5	1.5	1.5	1.5
Resolution MCS2 [nm]	1 (S)		1 (S)	1 (S)	1 (S)	1 (S)	
Breadboard Mount	Dimensions [mm] L x W x H	65 x 65 x 58	65 x 65 x 58	65 x 65 x 62	65 x 65 x 62	65 x 65 x 59	65 x 65 x 59
	Center of Stage Z above Ground [mm]	42 (31.5 ... 52.5)	42 (31.5 ... 52.5)	47 (36.5 ... 57.5)	47 (36.5 ... 57.5)	43 (32.5 ... 53.5)	43 (32.5 ... 53.5)
Direct Mount	Dimensions [mm] L x W x H	38 x 32 x 53	38 x 32 x 53	42 x 40 x 57	42 x 40 x 57	48.5 x 32 x 54	48.5 x 32 x 54
	Center of Stage Z above Ground [mm]	37 (26.5 ... 47.5)	37 (26.5 ... 47.5)	42 (31.5 ... 52.5)	42 (31.5 ... 52.5)	38 (27.5 ... 48.5)	38 (27.5 ... 48.5)

SMARBOTIC – Typical Positioning Systems

4 DoF Positioning Systems



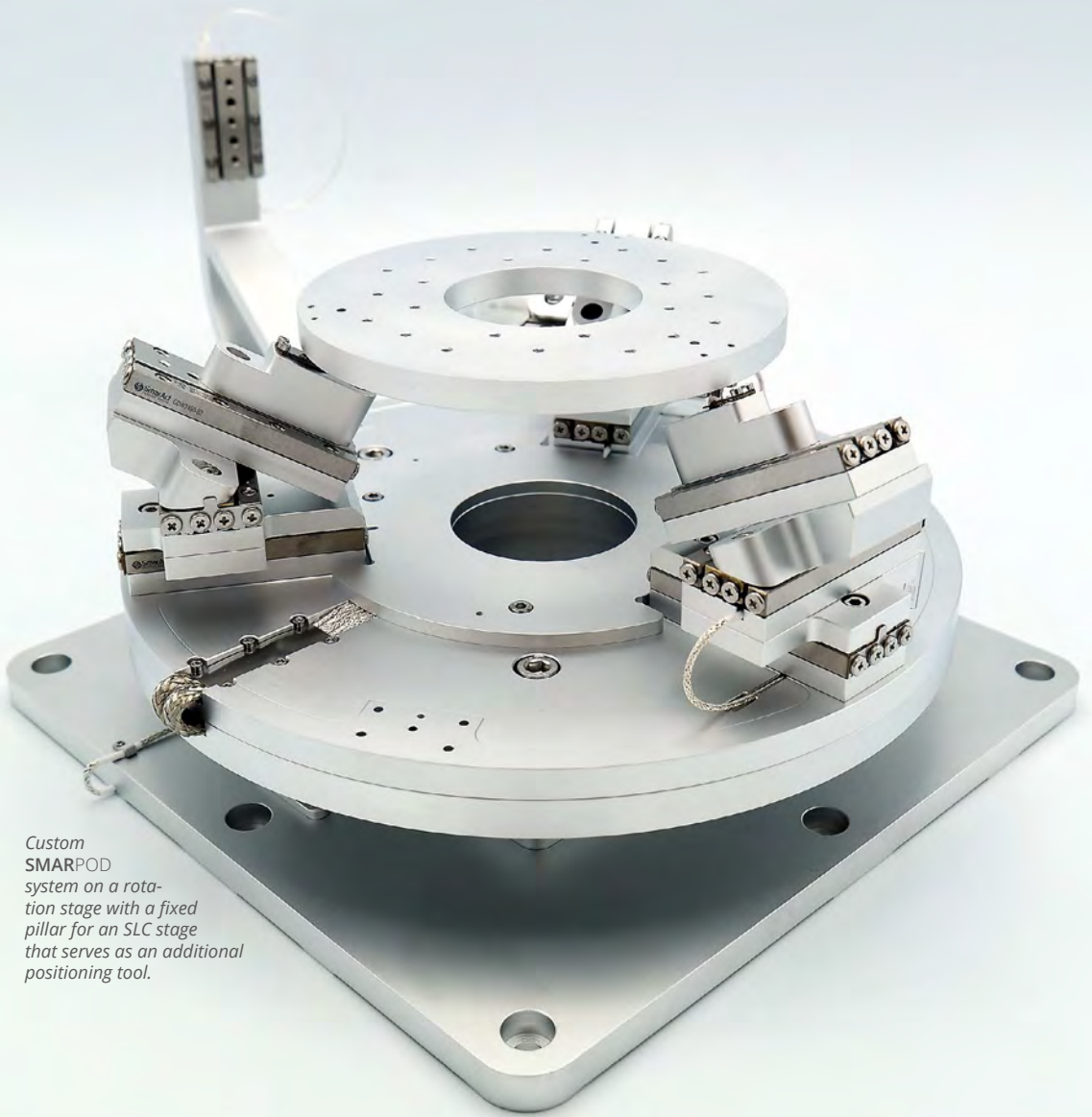
XYZR-XYZ SLC17:30 R SRP20:13 is a positioning system with 4 DoF consisting of three SLC-1730 linear stages and one SR-2011 rotation stage.



Detailed technical drawings and 3D models can be found on our website.

Systems with 4 degrees of freedom consist of three linear stages of the SLC or CLS series and a rotation stage of the SR series in a XYZR configuration. These setups allow the rotation center to be precisely positioned within the working range of the three linear stages.

		XYZR-XYZ SLC17:30 Z SRP20:11	XYZR-XYZ CLS32:32 Z SRP32:11
	Degrees of Freedom	4	4
	Linear Stage X	SLC-1730	CLS-3232
	Travel X [mm]	21	21
	Linear Stage Y	SLC-1730	CLS-3232
	Travel Y [mm]	21	21
	Linear Stage Z	SLC-1730	CLS-3232
	Travel Z [mm]	21	21
	Rotation Stage	SR-2013	SR-3211
	Travel Θ	unlimited	unlimited
	Payload [N]	1.3	3.3
Resolution MCS2 [nm]		1 (S)	
Breadboard Mount	Dimensions [mm] L x W x H	68 x 65 x 57	79 x 65 x 70
	Center of Rotation Stage above Ground [mm]	41.5 (31 ... 52)	43 (32.5 ... 53.5) (32.5 ... 53.5)
Direct Mount	Dimensions [mm] L x W x H	50 x 30 x 52	62.5 x 45.5 x 65
	Center of Rotation Stage above Ground [mm]	36.5 (26 ... 47)	38 (27.5 ... 48.5)



Custom SMARPOD system on a rotation stage with a fixed pillar for an SLC stage that serves as an additional positioning tool.

SMARPOD motion systems offer six degrees of freedom similar to classical hexapod systems while guaranteeing highest resolution and repeatability. Compared to serial kinematic systems, parallel kinematic SMARPODs exhibit a higher stiffness. A user-friendly software package allows easy integration into your own control environment assuring a very short setup time.

Customizability

SMARPODs, like all other SmarAct products, are highly customizable. Whether your application requires only a modified base or top plate or a completely different configuration, feel free to contact us to discuss your requirements and the most appropriate solution. Let us help you bring your ideas to life.

Mounting Options

The SMARPOD motion systems can be mounted in horizontal or up-side down orientation. Please mention the planned mounting orientation in your application when contacting us. We will help to find or adjust the SMARPOD motion system to realize the desired mounting configuration.

Control in Cartesian Coordinates

Calculation of the kinematics model and device control is encapsulated in a software package. Programming interfaces and graphical user interfaces allow to move the SMARPOD in Cartesian coordinates (X, Y, Z, R_x, R_y, R_z).

User-Definable Pivot Point and Axis Alignment

One great advantage of the SMARPOD is the possibility to freely set the rotations' pivot point. By defining the center of rotation, the system can precisely rotate around any addressable point in space. This is very helpful for many applications, e.g., the alignment of optical components. In addition, the base coordinate system can be shifted and rotated allows the SMARPOD axes to be aligned in customer or application specific environments.

Apertures

All SMARPODs with circular base plates include an aperture in the base and top plate. These apertures allow to gain access from beneath the positioning system to electrically connect the sample or to get optical access to mounted components.

Environmental Specific

For applications that require vacuum conditions most of our SMARPODs are available in high (10^{-6} mbar) and ultra-high vacuum (10^{-11} mbar) compatible versions. Furthermore, they can also be made from fully non-magnetic materials to be used in applications utilizing charged particle beams or high magnetic fields.

High Resolution and Repeatability

A backlash-free mechanical design makes it possible to achieve a movement performance of the positioning system which is in the same order of magnitude as for our single positioners.

SMARBOTIC – SMARPOD

Series Overview



	70.42	110.45	CLS-32	225.75	P-SLC-17	P-SLC-24	P-CLL	
Mechanical	Travel X [mm]	11	20	20	42	50	102 †	330 †
	Travel Y [mm]	11	20	20	42	30 †	62 †	62 †
	Travel Z [mm]	6	11	11	24	10	17	17
	Rotation Θ_x [°]*	22	23	22	24	25	33	33
	Rotation Θ_y [°]*	23	26	25	27	22	33	33
	Rotation Θ_z [°]*	31	38	38	41	16	36	36
	Max. Normal Force [N]	5	5	5	5	4	5	2.5
	Max. Horizontal Force [N]	2.5	2.5	2.5	2.5	2	2.5	2
	Dimensions Base Plate [mm]**	Ø 70	Ø 110	Ø 123.7	Ø 225	110 x 70	195 x 91	554 x 45
	Height above Ground [mm]	42	45	54.5	75	67.4	81	72
Weight [g]	200	410	520	2060	680	1890	2900	
Closed-Loop	Smallest Increment [nm]	1						
	Smallest Increment [μ °]	3						
	Uni-Directional Repeatability MCS2 [nm] **	± 50						± 100
Options	Vacuum	HV (10^{-6} mbar); UHV 10^{-11} mbar)						
	Non-Magnetic	--	yes (-NM)					--
	Orientation	0°/180°				--		
	Material	on request						
	Additional Mounting Posts	--	yes				--	
	High Stiffness	--	yes					
	Alternative Travel	--			on request			
	High-Load	--	yes					

† Other sizes upon request.

* Values given for a pivot point at the surface of the top plate.

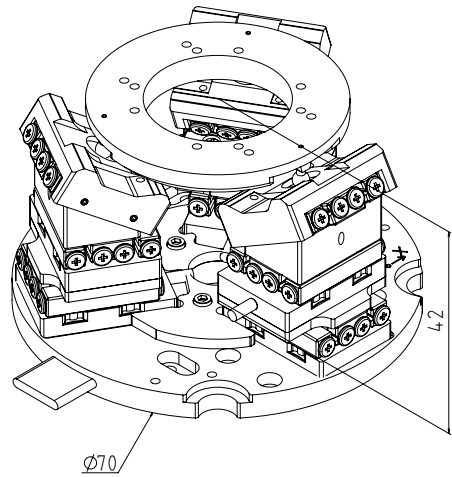
** Measured at 20 mm above the top plate, over the full range and for each dimension separately. An improvement can be expected for shorter travel ranges.

*** Total dimensions of the overall system might be larger for different poses. Compare CAD model for further information.

Closed-loop resolution and repeatability differ depending on the sensor type selected. For more information, please see the different sensor types on page 13.



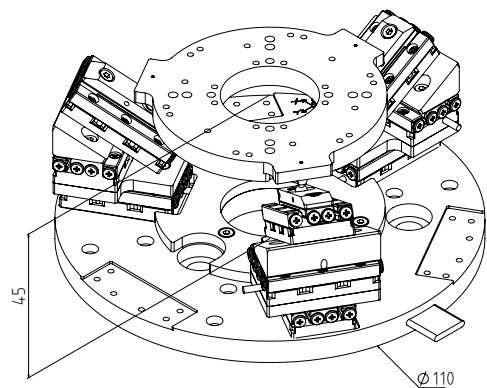
SMARPOD 70.42 is the most compact 6D positioning system.



Detailed technical drawings and 3D models can be found on our website.



SMARPOD 110.45 is a mid-size hexapod-like 6D positioning system.



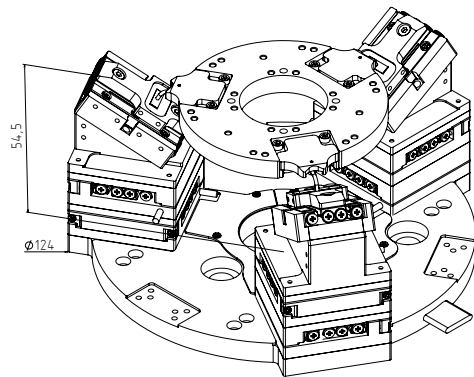
Detailed technical drawings and 3D models can be found on our website.

SMARBOTIC – SMARPOD

Hexapod-Like



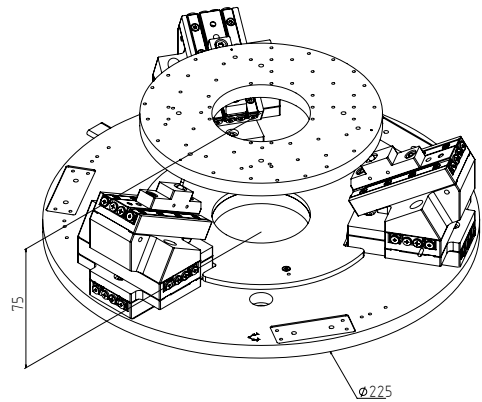
SMARPOD CLS-32 is equipped with exchangeable drive units.



Detailed technical drawings and 3D models can be found on our website.



SMARPOD 225.75: A large size hexapod-like 6D positioning system.

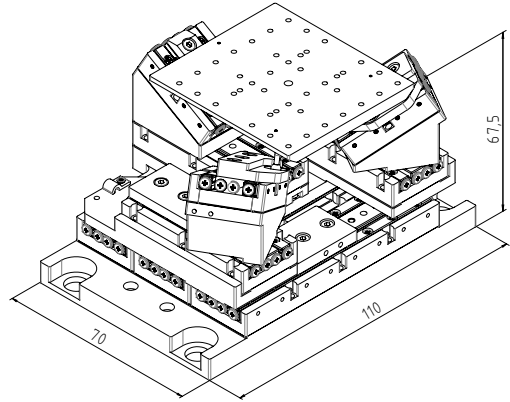


Detailed technical drawings and 3D models can be found on our website.

SMARBOTIC – SMARPOD Hexapod-Like



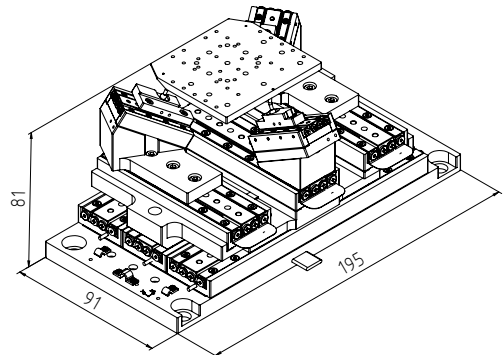
SMARPOD P-SLC-17 is a mid-size SMARPOD based on SLC-17 stages in a parallel orientation.



Detailed technical drawings and 3D models can be found on our website.



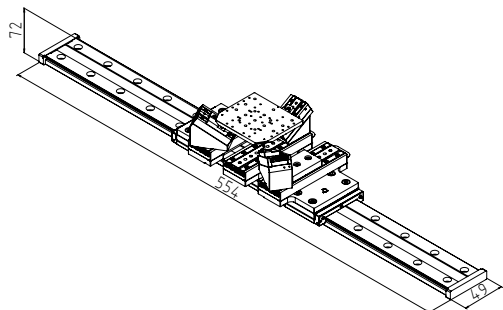
SMARPOD P-SLC-24 is a mid-size SMARPOD based on SLC-24 stages in a parallel orientation.



Detailed technical drawings and 3D models can be found on our website.



SMARPOD P-CLL is a SMARPOD based on three carriages of the CLL series.



Detailed technical drawings and 3D models can be found on our website.

SMARBOTIC – SMARPOD Control System and Software

SmarAct **SMARPODs** can be controlled in different ways. In addition to the **SMARPOD** hardware, a control software with graphical user interfaces, a software development kit, programming examples in C/C++, Python® and LabVIEW™ are included. For details about SmarAct's **SMARPOD** control software please refer to page 197. Further information about SmarAct's precision tool commander can be found on page 124. The included LabVIEW™ SDK provides a tool palette with all the necessary VIs to integrate the **SMARPOD** into your own control application. The programming examples are well commented and the SubVIs include

an in depth documentation about their functionality and parameters. All kinematic calculations are performed within a software layer called by the SubVIs, so you can move every **SMARPOD** in Cartesian coordinates – without having to perform inverse kinematic calculations for the positioning system. Therefore, integrating of a **SMARPOD** into your own application is an easy-to-perform task guaranteeing very short implementation times.

E1 Initialization.vi Block Diagram

1. Initialize the SmarPod. Store the returned smarpodId and pass it to all subsequent commands.
2. Configure the sensor power-mode
3. Calibrate (this step is only necessary if the SmarPod is connected for the first time to the MCS)
4. Find the reference marks of the positioners.
The frequency that is set with SET MAX FREQ is used during reference finding.
The find.ref. method can be selected (not all methods are available for all SmarPod models) and configured. The command SET FINDREF DIRECT, sets the preferred direction of movements during find.ref. The parameter of this function can be a combination of flags or'ed together.
5. Read the current physical pose
6. Use the SmarPod
7. Release

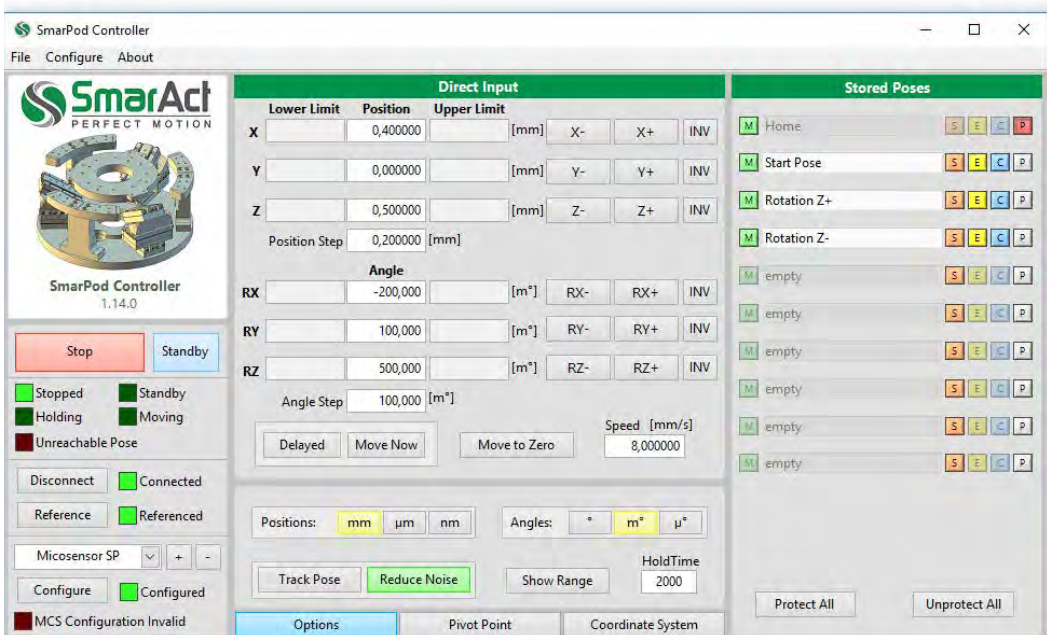
Context Help: SetAcceleration.vi

smarpodId accelerationControl acceleration error in (no error) error out

Description
Sets the speed for SmarPod movements or disables speed-control. The speed is the speed of the fastest moving positioner.

Parameters:

- smarpodId (unsigned 32bit, input - The SmarPod id.
- speedControl (boolean, input - If set to false, speed-control is disabled.
- speed (double, input - The speed (in m/s), used only if speedControl is true.



SMARPOD control software for all current SMARPOD models. More information can be found on page 77.

SmarAct Hand Controller

Software is only one way to control SmarAct's SMARPODs. A hand held controller with knobs and buttons which offer a more tactile feedback can be used in parallel to the graphical user interface. The universal SmarAct hand controller is connected via USB to the PC running the SMARPOD control software offering six turning knobs to control each translational and rotational degree of freedom. It also lets you store and recall poses or position sets from your fingertips.





The TRIPOD 92-6DoF offers long travel ranges on X and Y axis while maintaining a small footprint.

The TRIPOD product series offers highly modular multidimensional positioning systems that combine the versatility of serial kinematics and the compactness of parallel kinematics in one hybrid design.

Customizability

The TRIPOD motion system can be mounted in horizontal or up-side down orientation. Please mention the planned mounting in your application when contacting us. We will help to find or adjust the TRIPOD motion system to realize the desired mounting.

Mounting Options

The TRIPOD motion system can be mounted in horizontal or up-side down orientation. Please mention the planned mounting in your application when contacting us. We will help to find or adjust the TRIPOD motion system to realize the desired mounting.

Control in Cartesian Coordinates

Calculation of the kinematics model and device control is encapsulated in a software package. Programming interfaces and graphical user interfaces allow to move the TRIPOD in Cartesian coordinates (X, Y, Z, R_x, R_y, R_z).

User-Definable Pivot Point

One great advantage of the TRIPOD is the possibility to freely set the pivot point in three degrees of freedom X, Y and Z . Thereby defining the center of rotation for all axis allows you to precisely rotate around any addressable point in space.

User-Definable Coordinate System

The coordinate system of each TRIPOD model can be changed with the provided software packages to align the motion system with the specific user application.

Environmental Specific

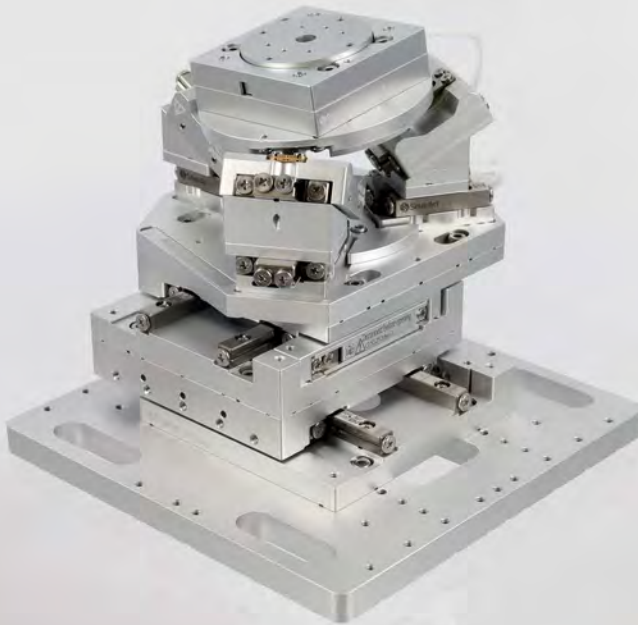
For applications that require vacuum conditions the SmarAct TRIPODs are available in high (10^{-6} mbar) and ultra-high vacuum (10^{-11} mbar) compatible versions. Furthermore, they can also be made from fully non-magnetic materials to be used in higher magnetic fields.

High Resolution and Repeatability

A backlash-free mechanical design makes it possible to achieve a movement performance of the positioning system which is in the same order of magnitude as for our single positioners.

SMARBOTIC – TRIPOD

Hexapod-Like



The TRIPOD 52-6DoF is equipped with two CLS-52 linear stages and a continuous rotation stage on its top plate.



		52-6DoF	92-6DoF
Mechanical	Travel [mm]	31 (X); 31 (Y); 6 (Z)	63 (X); 63 (Y); 11 (Z)
	Travel [°]*	20 (Θ_x); 19 (Θ_y); 360 (Θ_z)	31 (Θ_x); 27 (Θ_y); 360 (Θ_z)
	Max. Normal Force [N]	3	3
	Max. Horizontal Force [N]	2.5	1.75
	Dimensions Base Plate [mm] ***	90 x 90	142 x 142
	Height above Ground [mm]	79.5	94.4
	Weight [g]	490	1430
Closed-Loop	Smallest Increment [nm]		1
	Smallest Increment [μ°]		3
	Uni-Directional Repeatability MCS2 [nm]**		± 50
Options	Vacuum	HV (10^{-6} mbar); UHV (10^{-11} mbar)	
	Non-Magnetic	--	yes
	Orientation	on request	
	Material	on request	
	High Stiffness	--	yes

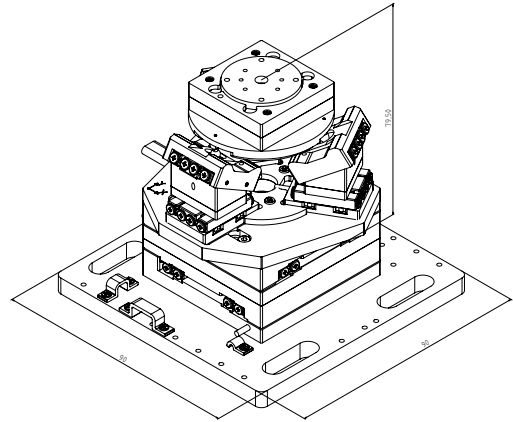
* Values given for a Pivot point at the surface of the top plate.

** Measured at 20mm above the top plate, over the full range and for each dimension separately. An improvement can be expected for shorter travel ranges.

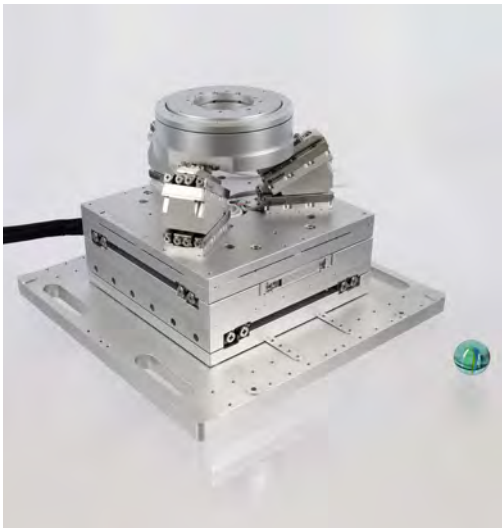
*** Total dimensions of the overall system might be larger for different poses. Compare CAD model for further information.



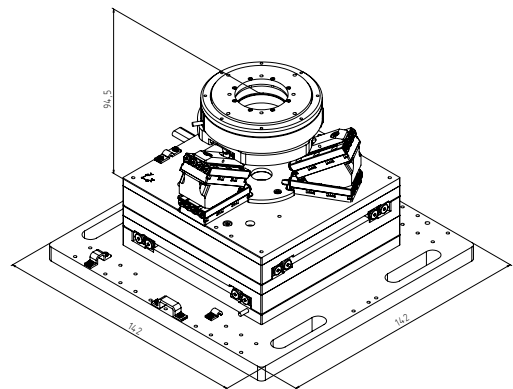
TRIPOD 52-6DoF is compatible with the CLS-52 series. It consists of a tip-tilt stage with an SR-3211 rotation stage on top.



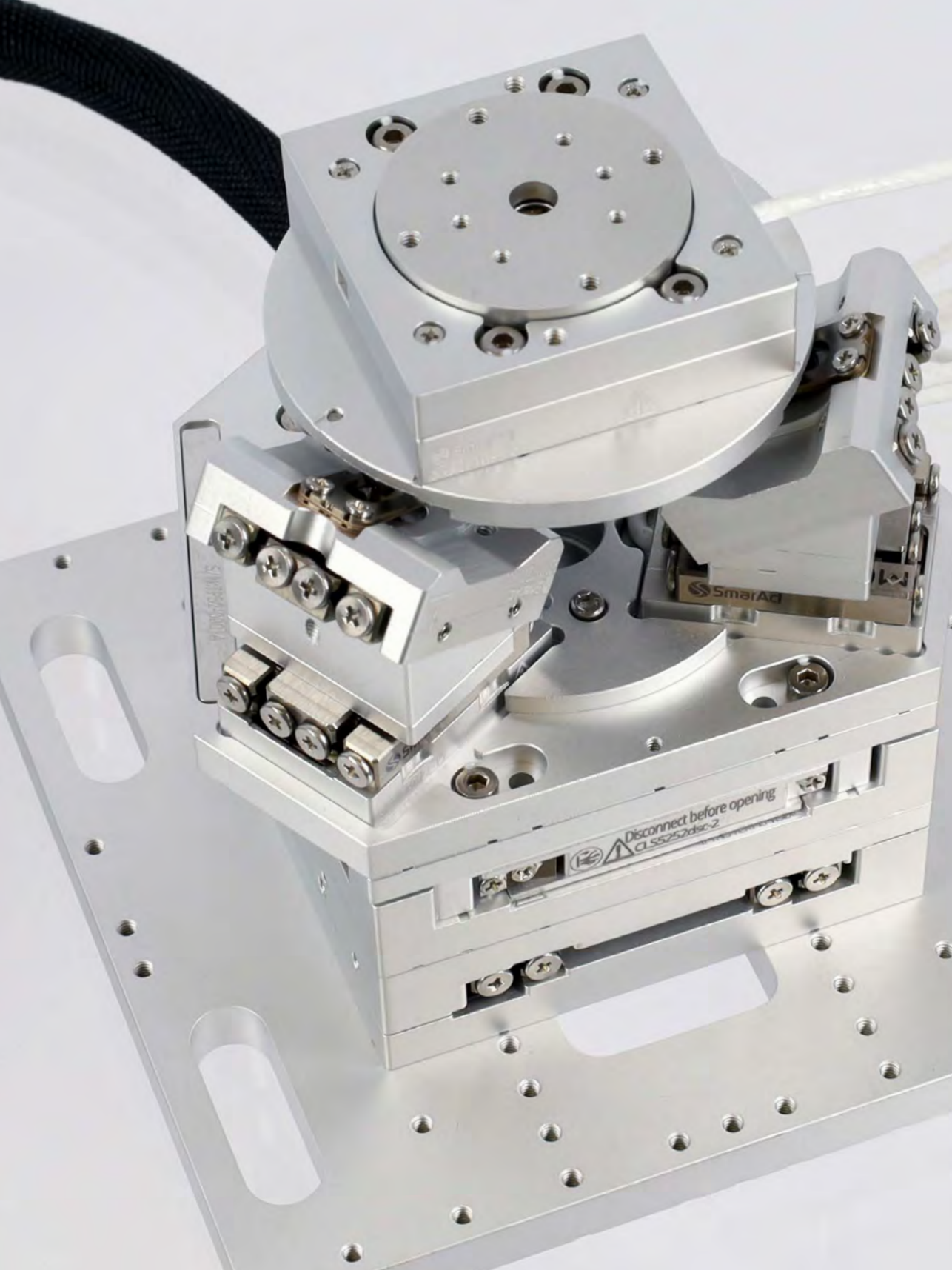
Detailed technical drawings and 3D models can be found on our website.



TRIPOD 92-6DoF is compatible with the CLS-92 series. It consists of tilt stage, ready to mount an SR-4011 rotation stage on top.

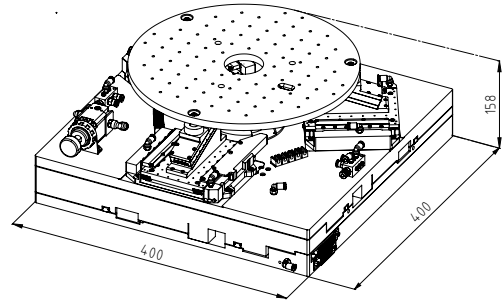


Detailed technical drawings and 3D models can be found on our website.



SMARBOTIC – TRIPOD

Electromagnetic TRIPOD

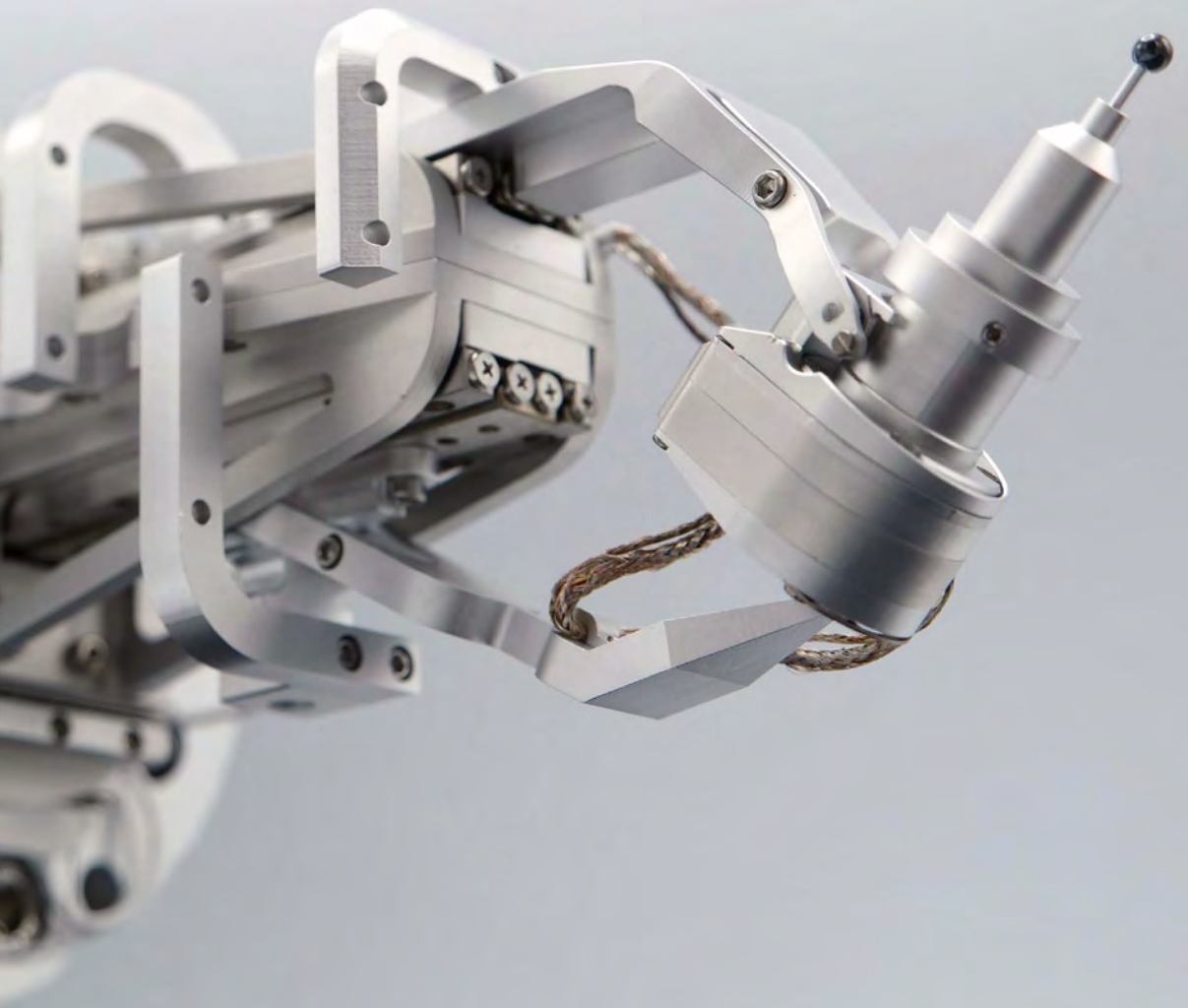


Detailed technical drawings and 3D models can be found on our website.

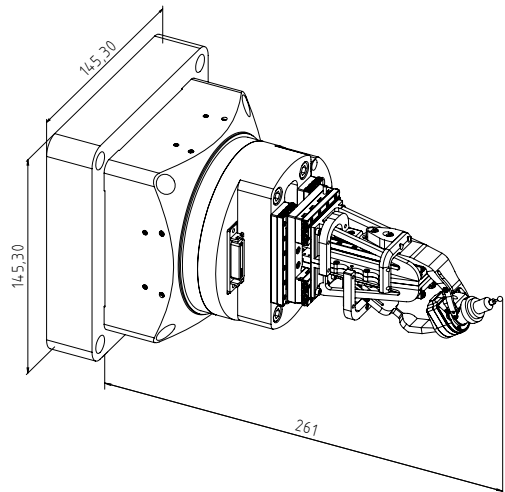
The EM TRIPOD 400-5Dof is based on a core consisting of three SMARSHIFT MLS-92122 stages that provide Z, Rx and Ry movements. A SMARSHIFT MLL-400 positioner completes the system with degrees of freedom in X and Y and axes. The EM TRIPOD stands out for its large travel range in the XY plane and its dynamic performance. It also allows high loads (up to 8 kg) even at high velocities. In addition, the EM TRIPOD can be upgraded by a rotational axes providing full 6 DoF with unlimited R_z rotation.

The system is equipped with adjustable weight force compensation and pneumatic brakes for emergency stops. SmarAct offers customized options for the top plate (aperture, hole pattern, etc.) to empower a wide range of applications. In addition, the EM TRIPOD is also available in an upside-down version.

		EM TriPod 400-5Dof
Mechanical	Travel [mm]	200 (X); 200 (Y); 16 (Z)
	Travel [°]	6.5 (Θx); 7 (Θy); 0 (Θz)
	Max. Normal Force [N]	80
	Max. Horizontal Force [N]	Not allowed
	Dimensions Base Plate [mm]	400 x 400
	Height above Ground [mm]	158
	Weight [g]	27500
Options	Material	On request
	6DoF	On request
	Orientation	On request



*The overall compactness and the narrow outline of SmarAct's goniometer **SMARGON** makes it the perfect sample manipulator for any XRD setup.*



Detailed technical drawings and 3D models can be found on our website.

The **SMARGON** offers large rotation angles of 360° each around two axes, as well as an axis that can additionally tilt by about 90°.

This gives you the possibility to view an attached object from almost all sides and all orientations.

	ω	χ	φ	X	Y	Z
Travel Range	unlimited	0° ... 90°	unlimited	± 2 mm		
Resolution of Motion	< 100 μ°	< 20 μ°		< 5 nm		
Velocity	180 °/s	10 °/s	80 °/s	~10 mm/s		
Max. Sample Weight [g]	50					



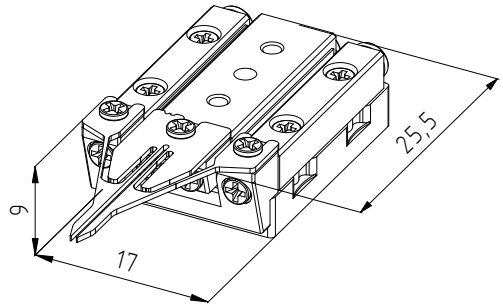
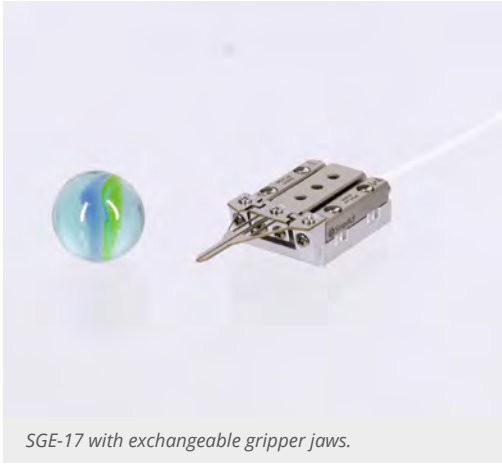
SmarAct gripper jaws are available in different designs optimized for specific applications. The gripper jaws shown feature the new magnetic quick-exchange option.

Precise handling of parts and tools at automated assembly lines and sample handling and manipulation in life science are often most crucial tasks. We have complemented our product portfolio with versatile gripping solutions to address the growing demand. SmarAct's micro-grippers consist of linear SMARSLIDE stages and gripping jaws that can be easily exchanged and customized if required. When equipped with a position sensor, the mi-

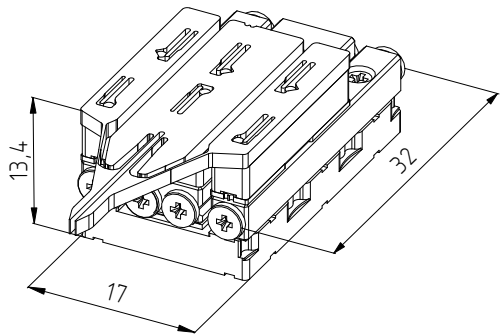
cro-grippers allow full control over the gripping process. In addition, force sensors integrated into the parallel micro-gripper SGP-17F allow to control not only the jaw opening but also the gripping force when handling fragile objects.

		SGE-17	SGQ-17	SGP-17F
Mechanical	Opening [mm]	< 1		< 20.5
	Gripping Force [N]	1		3.5
	Dimension [mm], L x W x H	17 x 25.5 x 9	17 x 32 x 13,4	30 x 35 x 14
	Weight [g]	14	28	40
	Jaw Types	Exchange	Quick Exchange	Solid
Open-Loop	Gripping Time [ms]	< 10		
	Gripping Resolution [nm]	< 10		1
Closed Loop	Sensor Types	S, L		
Material Options		Aluminum (standard); Black anodized (-BK)		
Vacuum Options		HV (10 ⁻⁶ mbar), UHV (10 ⁻¹¹ mbar)		

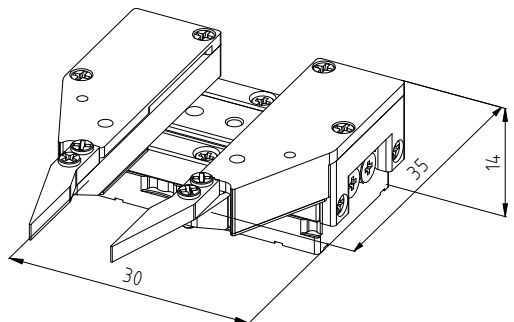
Closed-loop resolution and repeatability differ depending on the sensor type selected. For more information, please see the different sensor types on page 13.



Detailed technical drawings and 3D models can be found on our website.



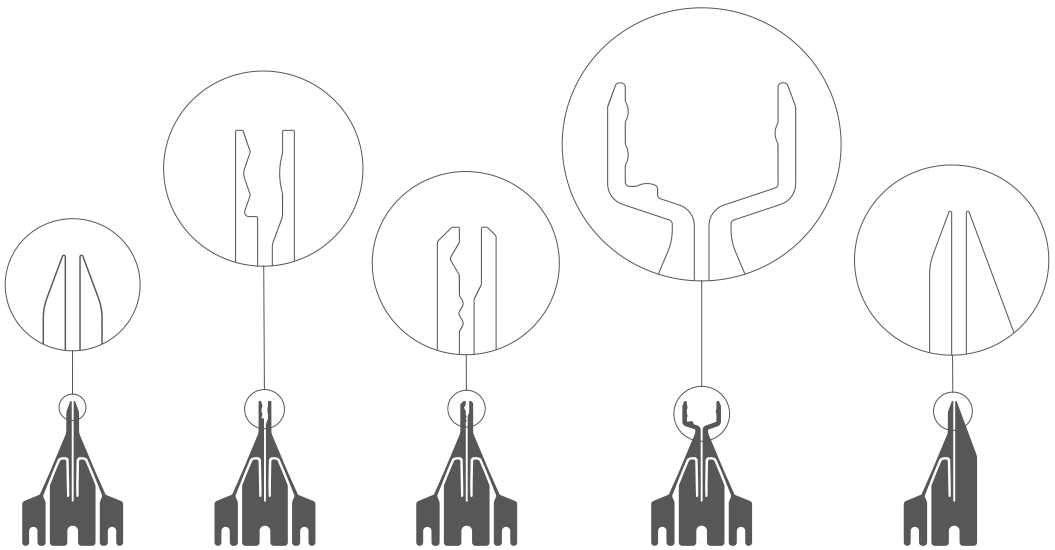
Detailed technical drawings and 3D models can be found on our website.



Detailed technical drawings and 3D models can be found on our website.

SMARBOTIC – Micro-Grippers

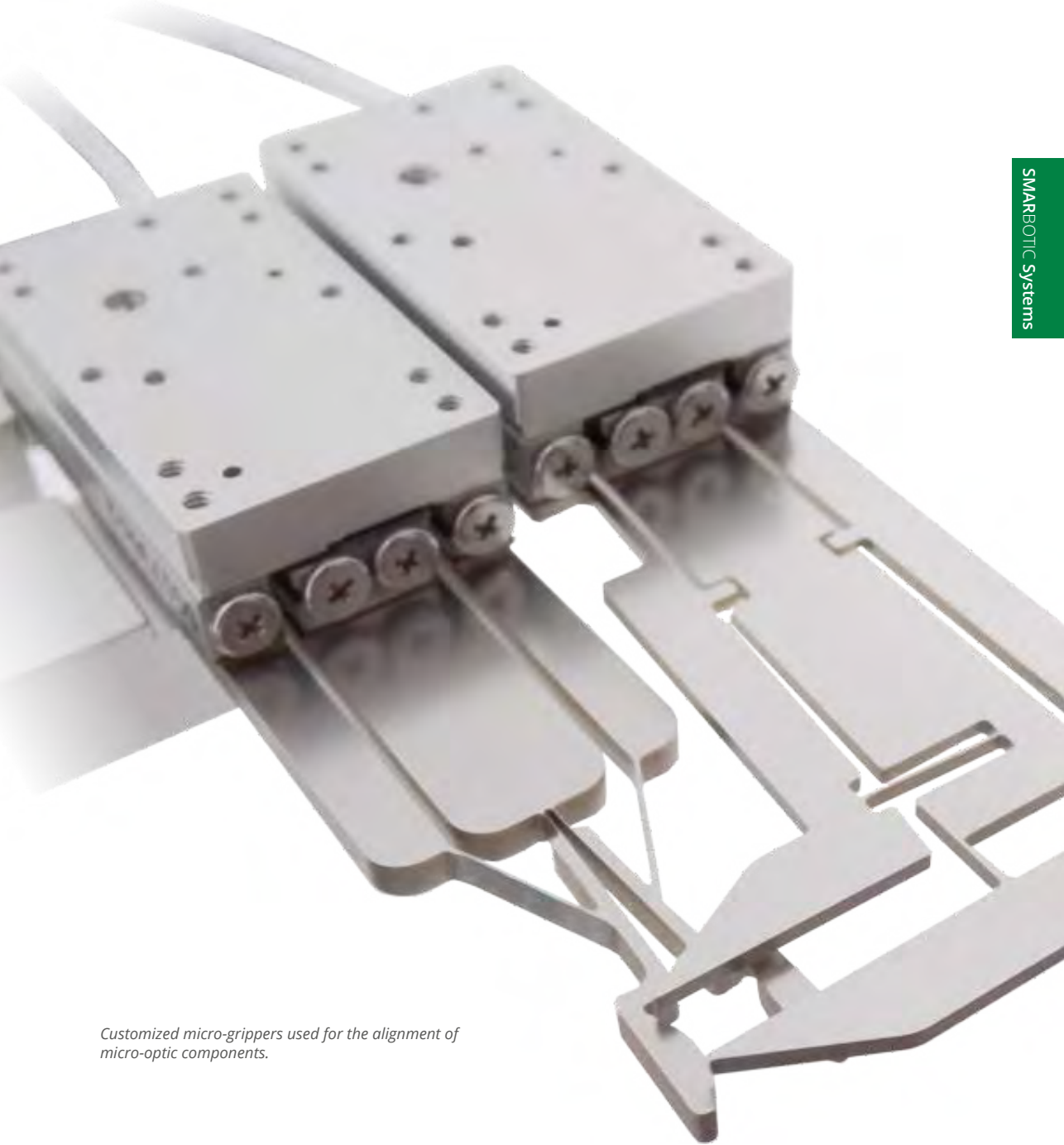
Gripper Jaws



Standard gripper jaws for the SGE series.

Over the years, various jaw shapes have been developed that are tailored for different object geometries and sizes. Examples include jaws for cylindrical, spherical and rectangular objects as well as dedicated designs to handle delicate optical components such as lenses and fibers. The gripper jaws are made of conductive material such as stainless

steel and available in different material thicknesses. All designs can be adapted and fully customized to meet your exact specific requirements. Please feel invited to contact our application specialists to design the jaw shape that perfectly matches the objects you would like to manipulate.



Customized micro-grippers used for the alignment of micro-optic components.

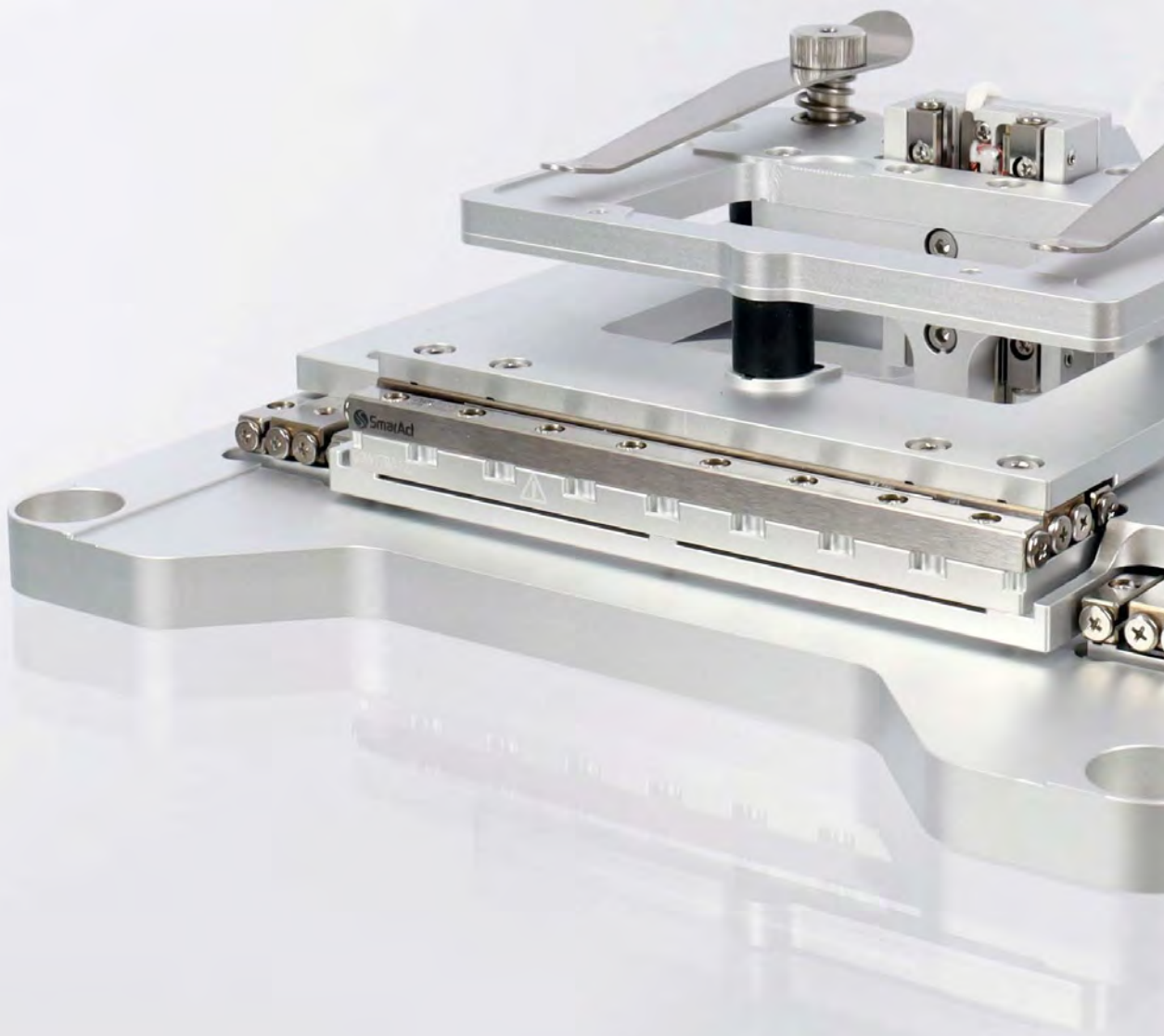
Microscope Stages and Manipulators

Overview



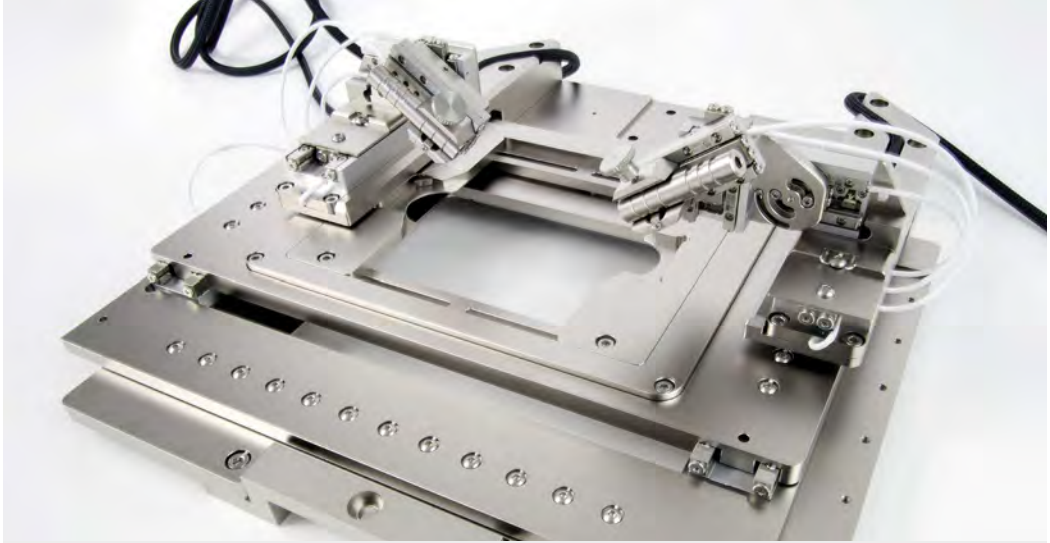
	SOM-180150	SOM-12090	SOM-8080	SOM-808030	SOM-505020	
Mechanical	Travel X [mm]	123	83	51	51	32
	Travel Y [mm]	103	63	51	51	32
	Travel Z [mm]		--		16	12
	Max. Normal Force [N]		≥ 20		--	
	Max. Lift Force [N]		--		1.8 - 2	
	Dimensions [mm], L x W x H	286 x 216 x 30	226 x 176 x 30	138 x 138 x 32.5	138 x 138 x 43.8	112 x 100 x 35
	Weight [g]	2380	1390	450	565	388
Open-Loop	Velocity [mm/s]	> 8				
	Resolution [nm]	< 1				
Closed-Loop	Sensor Resolution MCS2 [nm]	1 (S) 4 (L)				
	Repeatability, Full Stroke MCS2 [nm]	± 180 (S) ± 360 (L)	± 120 (S) ± 240 (L)	± 80 (S) ± 160 (L)	± 80 (S) ± 160 (L)	± 50 (S) ± 100 (L)
	Sensor Resolution (H) CU [nm]	50 (L)				
	Repeatability, Full Stroke (H) CU [nm]	± 1000 (L)				
	Material Options	Aluminum base as standard; black anodized (-BK)				
Vacuum Options	HV (10 ⁻⁶ mbar); UHV (10 ⁻¹¹ mbar)					
Non-Magnetic Options	Upon request					

Closed-loop resolution and repeatability differ depending on the sensor type selected. For more information, please see the different sensor types on page 13.



Microscope Stages and Manipulators

Introduction



Microscope stage with large free aperture and two micro-manipulators.

In the life sciences, precise sample handling and manipulation is the most important part of day-to-day operations at a microscopy workstation; therefore, the equipment used must be extremely precise and reliable.

Microscope Stages and Manipulators

To meet this requirements, SmarAct has developed microscope stages that not only allow the specimen to be positioned in two dimensions, but also enable the mounting of micro-manipulation systems for *in situ* sample manipulation. The microscope stages themselves are based on compact linear stages and allow long travel ranges with nanometer precision and highest closed-loop repeatability.

In addition to the standard universal object slide holder, unified well plate holders and petri dish holders are available. For easy and fast exchange of slides and coverslips in high throughput experiments, a magnetic holder is also available. Micro-manipulation systems are very versatile devices when it comes to handle pipettes, micro-knives, micro-grippers, micro-injectors or other mechanical or electrical probes. Our portfolio includes several different manipulators with three and four degrees of freedom for the most common tasks.

Larger stages support not just one, but two or more micro-manipulators, providing even more degrees of freedom for specimen manipulation.

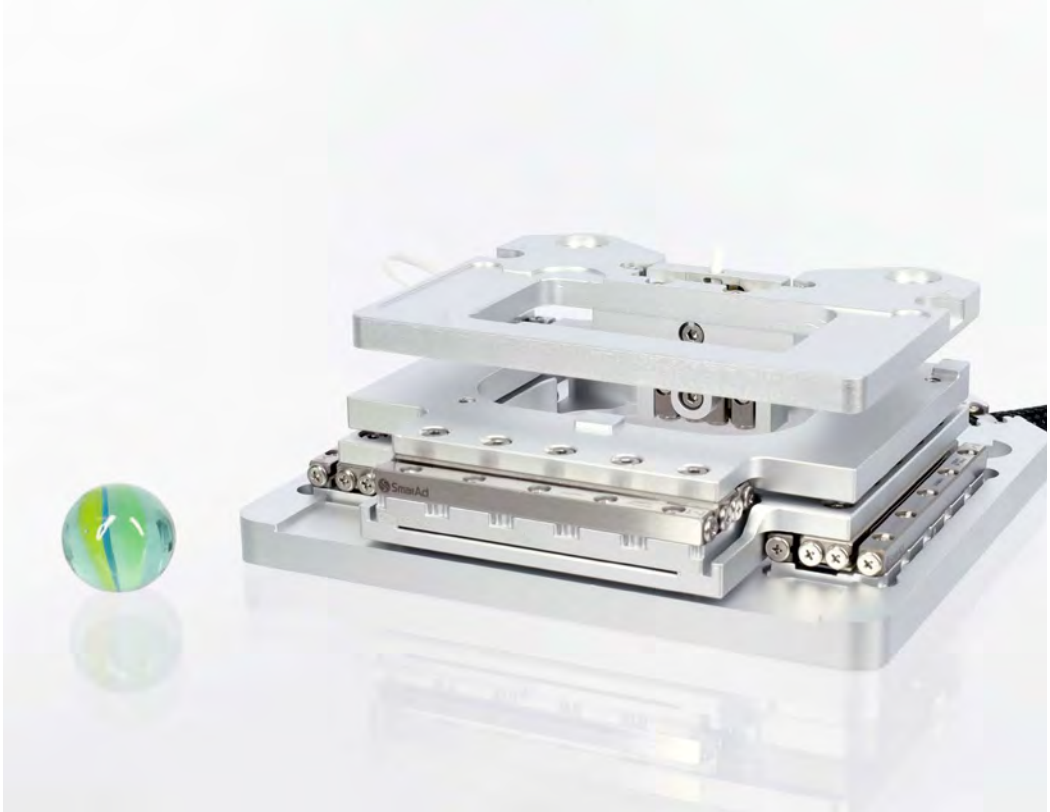
All manipulators can be moved completely independently and can of course be equipped with different tools and axis configurations.

Compatibility and Adaptability

The base plate of the microscope stages is bread-board compatible. Adapters for standard inserts ensure compatibility with common manufacturers. Cover plates and the stages themselves are highly customizable. You are always welcome to contact us to discuss adapting our stages to your specific microscope model or custom designed setup.



A customized four-axis micro-manipulator allows positioning of tools with nanometer precision in front of the objective lens.



Control Systems and Software

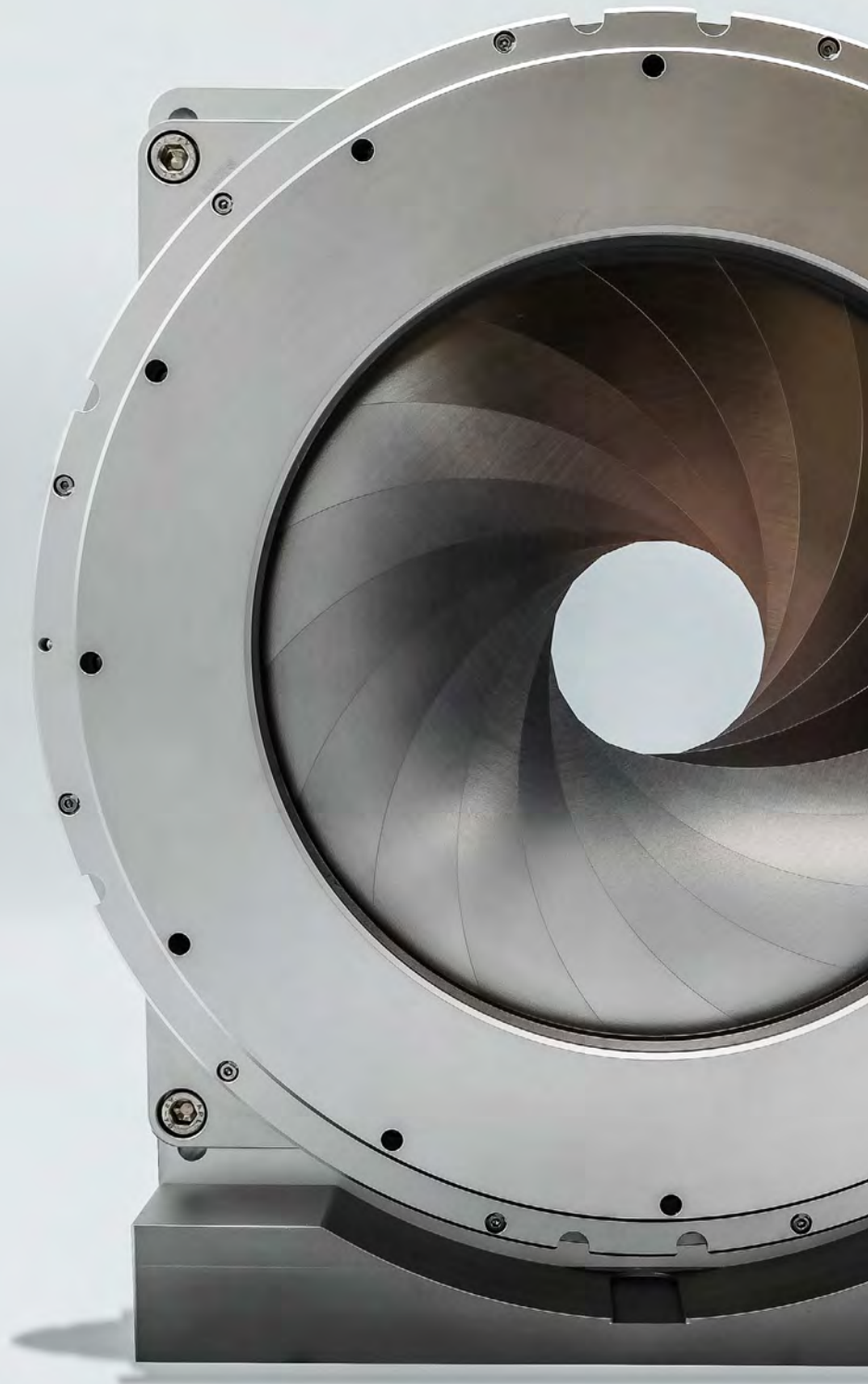
The XY stage and the micro-manipulators are controlled by SmarAct's MCS2 control system. The MCS2 allows to control up to 18 single positioning stages. This makes even highly versatile setups consisting of one XY stage and four micro-manipulators with four degrees of freedom each possible. The system and the manipulators can be controlled by different hand control devices with tactile buttons and joysticks or with SmarAct's precision tool commander software on your own PC (please refer to page 124). Integration of the XY system and the manipulators into your own control software can be realized with the help of the supplied software development kits which include documentation, libraries and programming examples for C/C++, Python® and LabVIEW™. Based on the control interface, the microscopy stage can easily be integrated into existing software frameworks. Even an integration into Micro-Manager, an open source software package for microscope image acquisition and de-

vice control by Open Imaging Inc., is available.



All microscope stages and components incl. micro-manipulators are also available with a black anodized surface finish.

Motorized Optomechanics



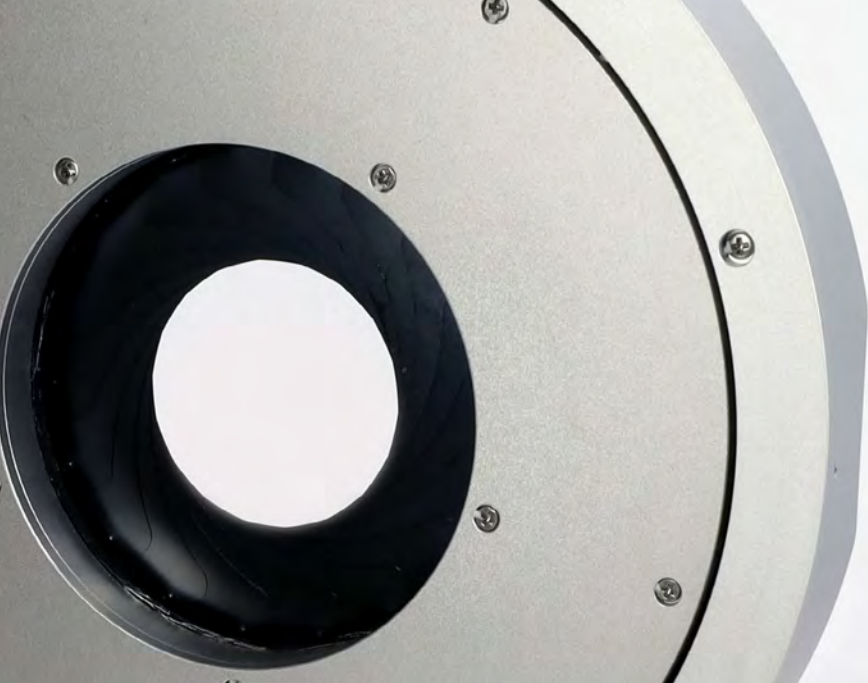


Customized iris diaphragm with an opening range from 20 mm to 160 mm.

Miniaturization, precision and modularity make positioning systems by SmarAct the optimal solution for complex setups and experiments in the field of optics.

In addition to various multi-axis positioning systems, SmarAct has developed a large number of dedicated optomechanical components like motorized tip-tilt mirror mounts, iris diaphragms, filter wheels, rectangular apertures and beam shutters. Combined with positioning sensors, they enable closed-loop position control and are perfectly suited for automated or remotely controlled experimental setups.

To address the high demand of in-vacuum optical setups, nearly all components are available as high vacuum or ultra-high vacuum variants. For setups where reflections have to be avoided, black anodized versions of the components are available. All presented optomechanical components and devices in this catalog section can be highly customized. Our application specialists are eager to discuss customized solutions to exactly match your requirements.



Iris Diaphragms

Motorized Optomechanics

Motorized iris diaphragms are used among others in the fields of optoelectronics, lasers and medical technology. They allow to control optical setups fully remotely. This is particularly advantageous in confined spaces such as chambers, cabinets, enclosures or simply in automation.

These precise optomechanical devices allow precise control of the amount of light and therefore an exact control of the projection and the size of the illuminated part. Due to the high quality materials used, the iris diaphragms are reliable over many

thousands of opening/closing cycles, even under extreme conditions.

The iris diaphragms can optionally be equipped with positioning sensors. This allows for closed-loop control of the aperture diameter. High vacuum and ultra-high vacuum compatible versions are also available as well as customized assemblies regarding aperture size, base materials and overall dimensions.

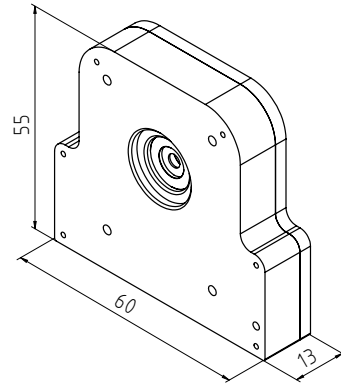
		SID-7	SID-18	SID-50
Mechanical	Aperture [mm]	0.5 ... 7	2 ... 18	5 ... 50
	Dimensions [mm], L x W x H	60 x 13 x 55	60 x 13 x 55	140 x 18 x 130
	Weight [g]	100	105	530
Closed-Loop	Opening Resolution [μm]	< 1		
	Opening Velocity [mm/s]	4	6	
	Uni-Directional Repeatability MCS2 [μm]	20		
Material Options		Aluminum as standard; Titanium base (-TI) and others on request		
Vacuum Option		--	HV (10^{-6} mbar)	

Motorized Optomechanics

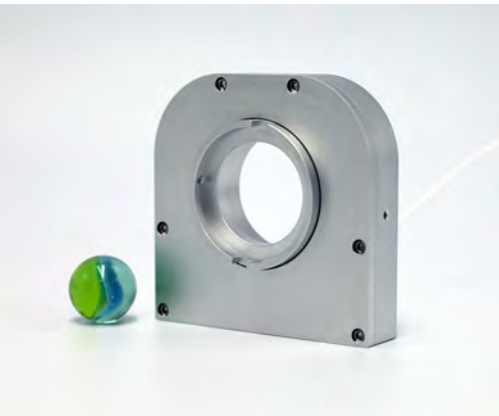
Iris Diaphragms



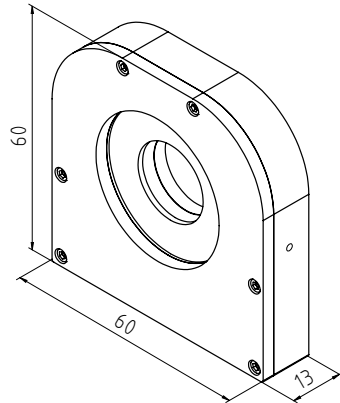
SID-7 is a motorized iris diaphragm with a maximum opening of 7 mm.



Detailed technical drawings and 3D models can be found on our website.



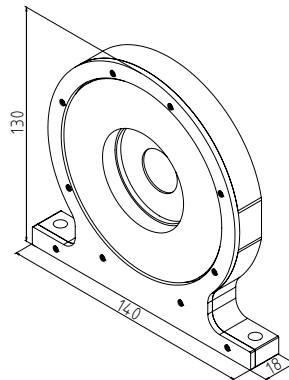
SID-18 is a motorized iris diaphragm with a maximum opening of 18 mm.



Detailed technical drawings and 3D models can be found on our website.



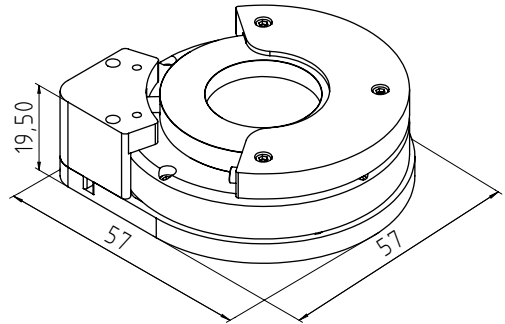
SID-50 is a motorized iris diaphragm with a maximum opening of 50 mm.



Detailed technical drawings and 3D models can be found on our website.

Motorized Optomechanics

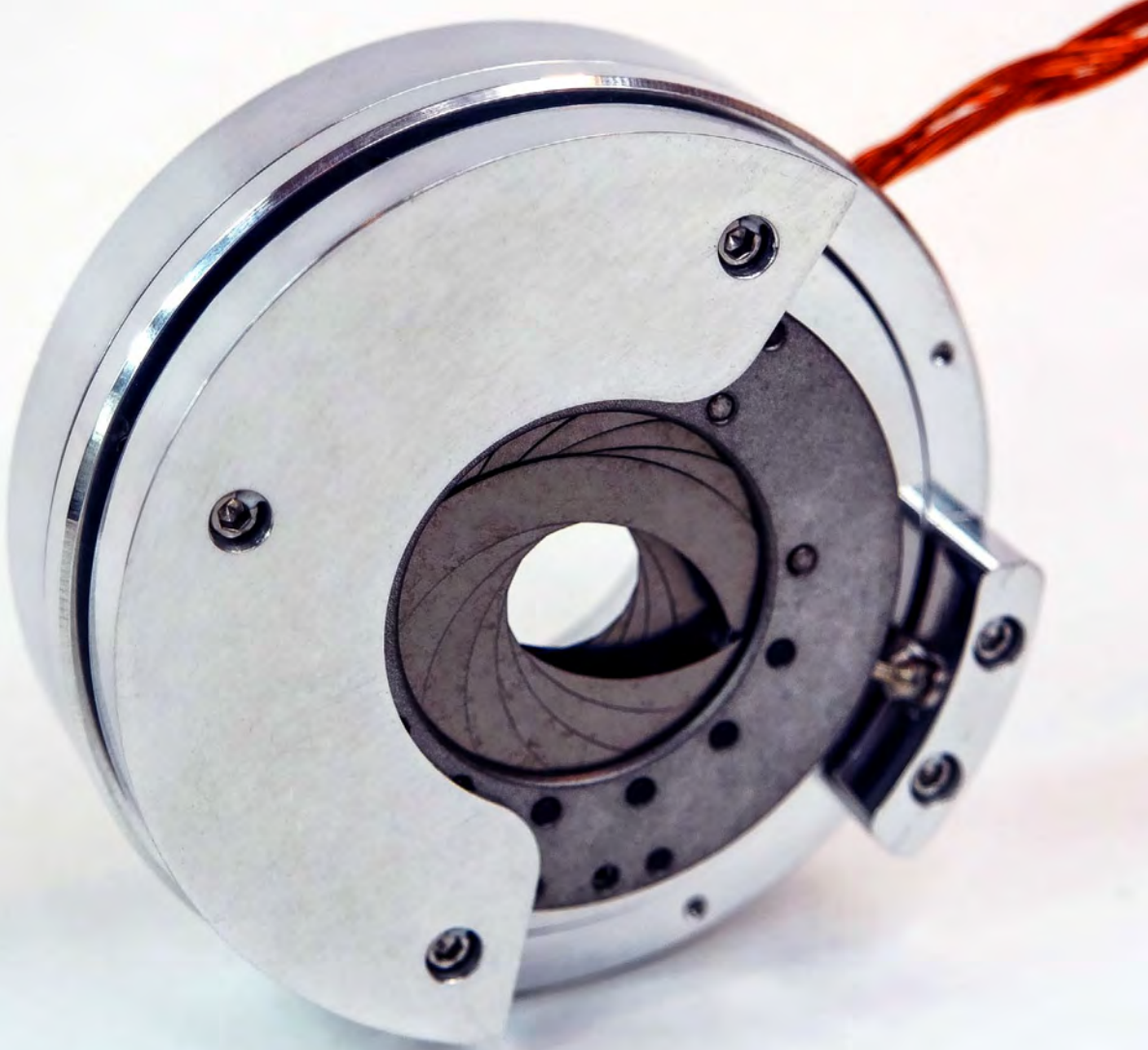
Iris Diaphragm SID-5714



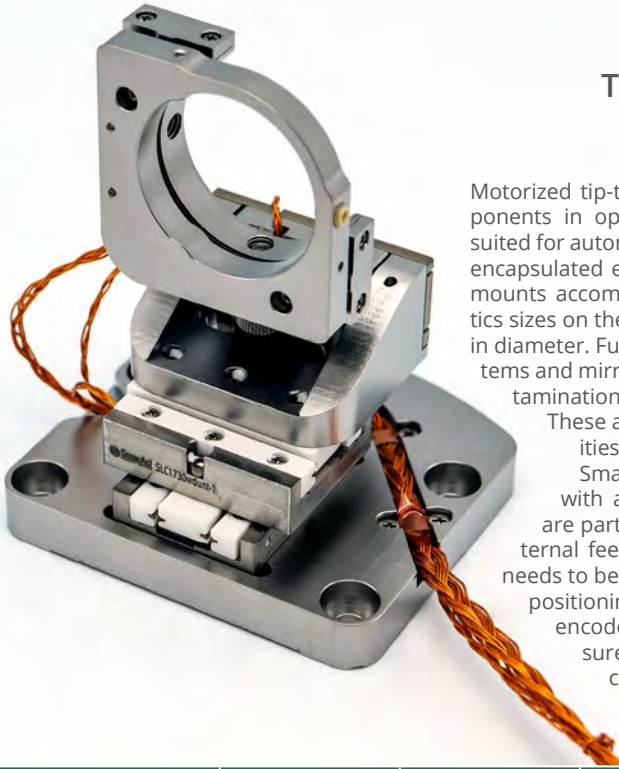
Detailed technical drawings and 3D models can be found on our website.

The SID-5714 iris diaphragm was especially designed as a modular component which consists of a motorized rotation stage and an iris diaphragm insert. Three different inserts are available, named ID-18, ID-22 and ID-25 according to their largest aperture opening.

		SID-5714		
		ID-18	ID-22	ID-25
Mechanical	Aperture [mm]	1.2	fully closing	4
	Dimensions [mm], L x W x H	57 x 19.9 x 57		
	Weight [g]	130		
Closed-Loop	Opening Resolution [μm]	< 1		
	Opening Velocity [mm/s]	6		
	Uni-Directional Repeatability MCS2 [μm]	20		
Material Options		Aluminum as standard; Steel base (-ST); Titanium base (-TI); Black anodized (-BK)		
Vacuum Options		HV (10^{-6} mbar); UHV (10^{-11} mbar)		
Non-Magnetic Option		Yes (-NM)		



SID-5714 with a ID-22 insert for fully closing possibility as a vacuum compatible version.



Tip-Tilt Mirror Mounts Motorized Optomechanics

Motorized tip-tilt mirror mounts are key components in optical systems. They are ideally suited for automation tasks and for actuation in encapsulated environments. The tip-tilt mirror mounts accommodate the most common optics sizes on the market from 0.5 up to 2 inches in diameter. Furthermore, UHV-compatible systems and mirror mounts qualified for low-contamination applications are available.

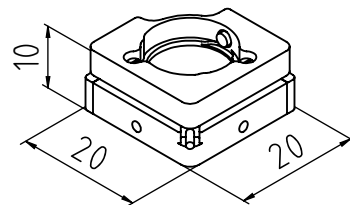
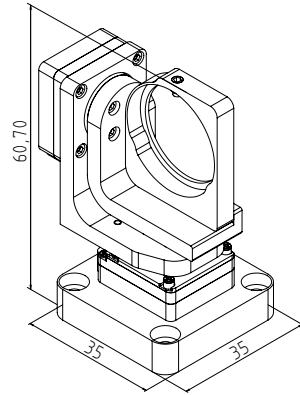
These are used in high-power laser cavities, for example.

SmarAct offers tip-tilt mirror mounts with active closed-loop control. They are particularly powerful tools when external feedback is not available and drift needs to be actively corrected or repeatable positioning is necessary. The integrated encoder is based on an inductive measurement principle and does not cause stray light.

	STT-2013	STT-12.7	STT-25.4	STT-50.8	
Mechanical	Dimensions [mm]	35 x 46 x 61	20 x 20 x 10	36 x 36 x 12	61 x 61 x 18
	Weight [g]	75	20	25	30
	Mirror Diameter [inch]	0.5; 1	0.5	1	2
	Tip Angles [°]	± 90	± 2	± 2.5 ± 2.15 (I)	± 1 ± 1 (I)
	Tilt Angles [°]	± 90	± 2	± 2.5 ± 2.15 (I)	± 1
Open-Loop	Velocity [°/s]	45		15	
Closed-Loop	Sensor Resolution [μ°]	MCS2: 25 (S)	--	MCS2: 80 (I) (H)CU: 100 (I)	
	Uni-Directional Repeatability [μ°]		--	MCS2: ± 300 (I) (H)CU: ± 1000 (I)	
	Reversal Error [μ°]		--	5000 (I)	
Material Options	Aluminum as standard: Steel base (-ST); Titanium base (-TI) and others an request				
Mechanical Option		--		Clear Edge (-CE)	
Cryogenic Options	--	Yes (Dimensions change to 20 x 20 x 13)		--	
Vacuum Option	HV (10 ⁻⁶ mbar); UHV (10 ⁻¹¹ mbar)				
Non-Magnetic Option	Yes (-NM)				

Closed-loop resolution and repeatability differ depending on the sensor type selected. For more information, please see the different sensor types on page 13.

Motorized Optomechanics Tip-Tilt Mirror Mount



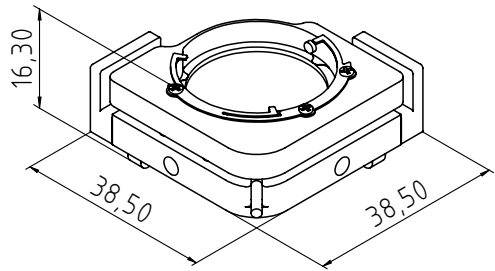


The STT-25.4 is a high precision motorized mirror mount featuring closed-loop position control for demanding laser applications and other optical experiments.

Motorized Optomechanics Tip-Tilt Mirror Mount



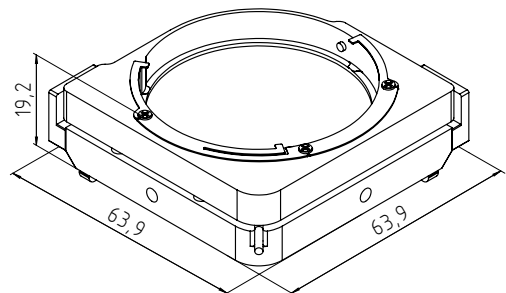
STT-25.4 with build in optical encoders. These motorized optical mounts provide compactness combines with closed-loop position feedback to your setup.



Detailed technical drawings and 3D models can be found on our website.



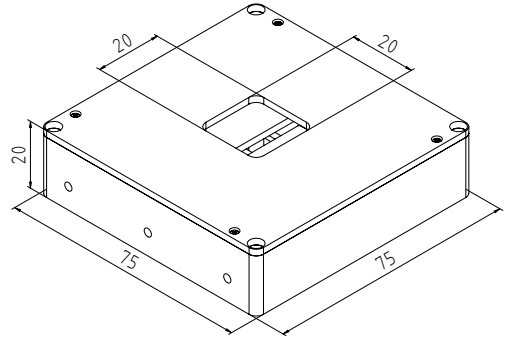
STT-50.8 is a tip-tilt mirror mount suitable for 2 inch mirrors or optical components. Since it is equipped with optical encoders it provides closed-loop position feedback.



Detailed technical drawings and 3D models can be found on our website.

Motorized Optomechanics

Rectangular Apertures



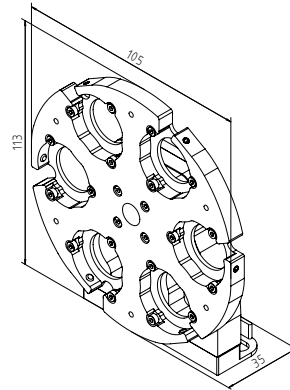
Detailed technical drawings and 3D models can be found on our website.

SmarAct's rectangular apertures can be used to define the optical path in optical experiments or to mask out individual parts of the optical setup, for example in front of a detector. Two different versions are available. The 1D version includes two individually movable blades whose edges are aligned parallel to each other. This allows the slit width and position to be adjusted between 0 and 20 mm in

the horizontal direction. The 2D version includes four independently movable blades aligned in two parallel pairs, allowing to set the width and height of the aperture as well as its position individually. In both versions optional position sensors allow for closed-loop positioning of each blade. Specialized versions are available for high and ultra-high vacuum environments.

		SMS-20-0	SMS-20-20
Mechanical	Dimensions [mm]	75 x 75 x 20	
	Weight [g]	185	275
Open-Loop	Velocity [mm/s]	> 20	
	Open-Loop Resolution [nm]	MCS2: < 1 (H)CU: < 50	
Closed-Loop	Sensor Resolution [nm]	MCS2: < 1 (S), 4 (L) (H)CU: 100 (L)	
	Uni-Directional Repeatability [nm]	MCS2: ±40 (S,L) (H)CU: ± 300 (L)	
Material Options		Aluminum as standard: Steel base (-ST); Titanium base (-TI); Black anodized (-BK)	
Vacuum Options		HV (10 ⁻⁶ mbar); UHV (10 ⁻¹¹ mbar)	
Non-Magnetic Option		Yes (-NM)	

Closed-loop resolution and repeatability differ depending on the sensor type selected. For more information, please see the different sensor types on page 13.



Detailed technical drawings and 3D models can be found on our website.

Filter wheels are available in different designs for different number of filters and different filter sizes of 0.5, 1, 1.5 and 2 inches.

	SFW-5-50.8	SFW-6-25.4	SFW-8-25.4	
Mechanical	Filter Size [inch]	2	1	1
	Filter Number	5	6	8
	Dimensions [mm]	165 x 35 x 172	105 x 35 x 113	114 x 31x 121
	Weight [g]	450	260	300
Closed-Loop	Sensor Resolution [μ °] MCS2: 15 (S), 60 (L) (H)CU: 1000 (L)			
Material Options	Aluminum base as standard; Steel base (-ST); Titanium base (-TI); Black anodized (-BK)			
Vacuum Options	HV (10^{-6} mbar), UHV (10^{-11} mbar)	HV (10^{-6} mbar)	HV (10^{-6} mbar), UHV (10^{-11} mbar)	
Non-Magnetic Option	Yes (-NM)		Yes (-NM)	

Closed-loop resolution and repeatability differ depending on the sensor type selected. For more information, please see the different sensor types on page 13.

Group 1		Group 2	
Ch. A (1)	Stopped	Closed Loop	
-130	798 137	Incr.	1 μ m
mm	μ m nm pm	Vel.	0pm/s
		Acc.	0nm/s ²
Ch. B (2)	Moving	Adv. Mode	
+12	659 526 940	Stp.	5
$^{\circ}$	m° μ° n°	Amp.	65535
		Frq.	10000
Ch. C (3)	Stopped	Simple Mode	
No sensor present		Speed	11

MCS2



MCS2 integrated hand control module with three channels, two joysticks and touchscreen interface.





Every successful positioning solution rests on at least two pillars. The first one is defined by the mechanical part of the solution, the second by the electronics and software to control it. SmarAct's sophisticated and easy-to-use control systems – together with our intuitive software solutions and software development kits (SDKs) – are the basis for a fast and easy integration of SmarAct's positioning technology into your application. SmarAct's portfolio of control systems consists of a wide variety of components optimized for different applications and integration scenarios. From single channel handheld controllers to rack-mountable modules with up to 18 channels, we are always glad to equip you with the appropriate tools.

Control Systems & Software

Control Systems Overview

SmarAct's control systems perfectly match our growing portfolio of positioning stages and systems. Tailored to application requirements and budget, a variety of control systems is available. From board-level controllers that can be integrated into your electronics project, to sophisticated and highly integrated control systems for daily use and

rack-mountable modules for positioning systems with up to 18 axes – SmarAct offers you the perfect control solution for your positioning application. The following table gives an overview of the different product series, their compatibility, controllability.

Controller Type	MCS2	SCU	EMS
Number of Channels	up to 18	1 or 3	2
Drive Technologies	SMARSLIDE  SMARSHIFT  SMARFLEX 	SMARSLIDE 	
Supported Position Sensors	S, L, I, PicoScale	L, I	L, I
Control Interfaces	USB, Ethernet, EtherCAT®	USB, RS232	TWI
Software and Drivers	Windows® and Linux® C-API, LabView™, Python®, ASCII Command Set		proprietary command set
Housing Options	Tabletop, 19" rack Or OEM board	Tabletop or OEM board	OEM board

Control Systems



The MCS2 is SmarAct's most versatile control system. The modular concept allows for a wide variety of well-suited solutions. See page 116 for details.



The SCU product line features single module solutions to control one or up to three stick-slip piezo positioners for cost optimized solutions. See page 121 for details.



The EMS product line is defined by an OEM single board controller that is exclusively designed to be integrated into existing electronics. See page 122 for details.



ECM 3 - The Embedded Control Module 3 is an extension for MCS2 control systems that allows to control multiple positioning systems like SmarPods and TRIPODS. The ASCII-based command language does not require any drivers on the client side. ECM 3 is available as a module compatible with the MCS2 rack housing.



SmarAct Hand Controller - The universal SmarAct Hand Controller is designed for manual operation of positioning systems with up to six degrees of freedom like the SmarPod, TriPod or any other SmarAct positioning system.

MCS2 - Modular Control System



SmarAct's MCS2 with an integrated hand control module to control up to three positioning stages.

The MCS2 is SmarAct's most versatile and powerful control system. Its stringent modular design approach makes it the perfect choice for all fields of applications. Product variants for three positioning stages up to the most complex multi-axis systems with up to 18 positioning stages are available to meet the specific requirements of each setup.

Key Features

User-Friendly

- Pre-configured modular system
- Service tool for easy setup and quick testing
- Programming examples for LabVIEW™, C++ and Python®.

Intuitive Hand Control Module

- Precise, manual control
- Graphical display for easy view
- Tactile control via 2D joysticks, buttons and knobs

Powerful

- Compatible with all of SmarAct's positioning stages with stick-slip piezo drives, hybrid drives and electromagnetic direct drives
- Supports S and L position sensors with nanometer resolution
- Is able to utilize SmarAct's **PICOSCALE Interferometer** as a high-resolution position sensor with picometer resolution
- Fast control loop with up to 50 kHz
- Compatible with all of SmarAct's positioning stages with stick-slip piezo drives, scanner piezo drives, hybrid drives, and electromagnetic direct drives

Smart

- Well documented property-based application programming interface (API)
- SCPI based ASCII command protocol for Ethernet interface
- Synchronous motion of multiple axes
- Complex customizable trajectories with up to 1 kHz trajectory point frequency
- Sensor power save mode for thermal management in vacuum applications
- Closed-loop positioning with velocity and acceleration control and high-resolution positioning accuracy
- Open-loop scan mode for sub-nm slip-free piezo motion
- Quiet mode for noise sensitive applications, especially in life science

Upgradeable

- In the field firmware update system
- Sophisticated firmware modules
 - Low-vibration mode to reduce vibrations caused by stick-slip motion
 - Advanced sensor calibration for increased accuracy

Versatile

- Optional I/O Modules
 - Trigger inputs for external synchronization
 - Configurable trigger outputs for each channel
 - 16-bit analog inputs e.g. as control-loop input
 - 16-bit analog outputs e.g. to control external components
- High speed data reader (HSDR) module for synchronous recording of position and external signals
- USB, Ethernet and EtherCAT® interface available

Equipped with the right drivers, you can command all our stages with the MCS2.

Control Systems & Software

MCS2 Modular Concept

Module	Variant	Description
Driver	SMARSLIDE (Stick-Slip)	These modules are the core component of every MCS2 configuration. They each include power circuits to drive up to three attached positioning stages and read sensor data from a sensor module to perform closed-loop position control. Several modules may be combined to control multiple of three stages.
	SMARSHIFT (Electromagnetic)	
	SMARFLEX (Piezo Scanner)	
Interface	USB	Provides connectivity to a control PC via USB.
	Ethernet	Provides connectivity to a control PC via Ethernet.
I/O	Digital	This module provides low-level digital interfaces, including the following functionalities: input trigger (Emergency Stop, Trajectory Streaming, Synchronization, Command Group Trigger), output trigger (Position Compare, Position Reached, Actively Moving), High Speed Data Reader
	Analog	This module provides low-level digital and analog interfaces, including the following functionalities: input trigger (Emergency Stop, Trajectory Streaming, Synchronization, Command Group Trigger), general purpose digital input, output trigger (Position Compare, Position Reached, Actively Moving), High Speed Data Reader general purpose digital output general purpose analog input, e.g. for control-loop feedback general purpose analog output
	EtherCAT®	Provides connectivity via EtherCAT® for a single Driver Module.
Sensor	SMARSLIDE	These modules convert the analog sensor data into digitized data which are processed by the driver modules.
	SMARSHIFT	
	SMARFLEX	
Hand Control	Internal	The hand control module offers a touchscreen, physical buttons and two analog joysticks to manually interact with the positioning system. Physical axes of the positioning system can be easily mapped to joystick axes for easy manual positioning. If the stages are equipped with position sensors, the actual position of the stage can be read on the module's touchscreen.
	External	

Depending on the specific configuration of the MCS2, the modules are integrated in one of the following housings:



Integrated Handheld

The integrated handheld is equipped with a main controller module including a communication interface and a human machine interface module. All together combined in a small and light tabletop housing.



Rack Housing

The modular rack housing with 6 slots is equipped with a main controller module including a communication interface and a backplane. It is compatible with 3-channel main control modules encapsulated into module carriers require one slot each. Consequently, up to six main controller modules can be mounted into the three height unit rack housing making it possible to control up to 18 positioning stages.



Tabletop Housing

Tabletop housings are equipped with a main controller module including a communication interface in the most basic configuration. Variants for controlling up to 12 positioning stages or integrated I/O modules are available within one compact desktop device.



Hand Control Module

Manual control of MCS2 controllers in rack and tabletop housings can be optionally controlled via an external hand control module which resembles the same user interface as the integrated handheld version.

Control Systems & Software

MCS2 Software Integration

MCS2 control systems can be operated with a PC via SmarAct's precision tool commander PTC (see page 124 for details). It can also be integrated into your own software environment in various ways. The PTC and a software development kit with programming examples in C/C++, Python® and LabVIEW™ are included.

The LabVIEW™ SDK offers a tool palette with all necessary VIs to integrate the MCS2 into your own control application. The programming examples are well commented and the SubVIs include an in-depth documentation about their functionality and parameters. Therefore, the integration of a MCS2 into your own application is easy to perform and guarantees very short implementation times.

The image displays a LabVIEW block diagram titled "MCS2_Example3_MoveLoop.vi Block Diagram on MCS2_ProgrammingExamples.lvproj/My Computer". The diagram is divided into two main sections: "findDevices" and "main loop (startemachung)".

findDevices Section: This section is enclosed in a "while" loop with a "Find Devices; Value Change" trigger. It contains a "findDevices" subVI. A text box explains: "MCS2 devices are identified by locator strings. To list all available devices the 'SA_CTL_FindDevices' function can be used. The returned device list is an string array with all found MCS2 devices." The logic involves filling a "Device Locator" array with locator strings, selecting the first locator, and outputting an "Error Out".

main loop (startemachung) Section: This section is enclosed in a "while" loop with a "True" trigger. It starts with a "Wait for the 'SA_CTL_CH_STATE_BIT_ACTIVELY_MOVING' (and 'SA_CTL_CH_STATE_BIT_CLOSED_LOOP_ACTIVE') state flags to be read as zero and reverse the movement direction instantly." The logic then checks if the movement was successful. A text box notes: "The SA_CTL_CH_STATE_BIT MOVEMENT_FAILED indicates a failed movement." The diagram uses logical "AND" operations to mask flags, checks the "Channel State" (e.g., 00000800), and outputs a "status code" and "Error Out". A text box states: "The channel error property may be read to determine the reason of the error."

SmartActCTL SDK: A window titled "SmartActCTL" is shown, displaying a search bar and a grid of VIs including: AbortStream, Calibrate, Cancel, CancelComm..., CancelOut..., CancelRequest, Close, CloseComm..., CloseStream, CreateOut..., FindDevices, FlushOutput..., GetEventInfo, GetLibraryVe..., GetRawHandle, GetResultInfo, Move, Open, OpenComm..., OpenStream, Reference, Stop, StreamFrame, WaitForEvent, and WaitForWrite. A "Generic Properties" window is also visible.


SA_CTL_VclassSA_CTL_SetPosition.vi: A subVI window is shown with the following details:

- channel:** SA_CTL_Handle
- Position:** error in (no error)
- error out:** error out
- Description:** This property holds the current position of a positioner. Note that it can only be used for positioners that have a sensor attached to it. To determine if a sensor is present the Channel State bit SA_CTL_CH_STATE_BIT_SENSOR_PRESENT may be polled. The interpretation of the read position value depends on the configured positioner type. The unit is pico meter (pm) for linear positioners and nano degree (n°) for rotatory positioners. Read the Positioner Base Unit property to distinguish between linear and rotatory positioner types.
- Parameter/Result:**
 - handle:** (SA_CTL_Handle) - The device handle that was returned from the OPEN function.
 - channel:** (signed 8bit) - Selects a channel of the connected devices. The channel index is zero based.
 - value:** (signed 64bit) - Position in <pm> or <ndegree>.

SCU – Simple Control Unit

The SCU product line of control systems includes one and three channel drivers to control stick-slip piezo stages with optional support for closed-loop positioning. All control systems of this product line are equipped with an USB or RS232 interface. USB devices are shipped with software development kits to guarantee easy and fast integration into your setup. As an alternative, all devices can be controlled using a simple ASCII command set. Besides the availability as fully integrated handheld controllers for desktop usage, the control system is also available as an OEM single board controller for integration into your product.



	SCU			
Compatible Stages	SMARSLIDE  stages (stick-slip drives)			
Number of Channels	1		3	
Supported Position Sensors	L, I			
Housing Type	Hand Control Module	OEM single board controller, tabletop	Hand Control Module	OEM single board controller, tabletop
Manual Control Features	Control knob and LED array	--	Control knobs, joystick and LCD	--
Available Interfaces	USB, RS232			
Software and Drivers	Drivers for Windows® and Linux® C-API, Python® SDK, ASCII Command Set			
Power Supply	12 V, 60 W			


Control Systems & Software

EMS

EMS – Embedded Microsensor System

The EMS consists of an OEM single board controller which was exclusively designed for integration into existing electronics. Because of its small size, it is perfectly suited to be integrated into your OEM product. The small footprint and the available TWI interface make it the best choice for your control electronics design.



	EMS-2D
Drive Technologies	SMARSLIDE  stages with stick-slip drives
Number of Channels	2
Supported Position Sensors	L, I
Power Supply	5 ... 7 V, 4 W/12 ... 24 V, 12 W
PC Interface	Two wire interface (TWI)
Scalability	Maximum 8 via TWI
Dimensions [mm]	58 x 32

ECM 3 Rack Module

The ECM 3 is designed to control multiple SmarAct positioning systems such as **SMARPODs** and **TRIPODs**. The ECM 3 rack module is compatible with the SmarAct **MCS2** rack and can be used in one **MCS2** rack housing together with up to four **MCS2** driver modules. This enables the control of two positioning systems with up to six axes or up to four positioning systems with three axes. Additional positioning systems can be integrated by connecting the ECM 3 to other rack units. The ECM 3 command language allows the configuration and control of all connected systems. As this is a purely text-based command language, no programming libraries or drivers are required on the controlling computer. The ECM 3 provides a network and a serial port for receiving commands and three USB ports. **MCS2** controllers can be connected to the ECM 3 via network or USB.



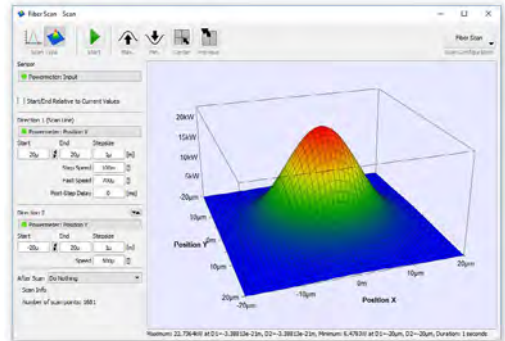
	ECM 3 Rack Module
Compatibility	MCS2 rack housing
Space Required	Two rack housing slots
Power Supply	12V or 48V
Controllable Systems	127
Positioner Compatibility	SmarPod, TriPod, TiltStage
PC Interface	Ethernet and RS232
MCS2 Interface	Ethernet and USB
Display	LCD display for configuration and status monitoring



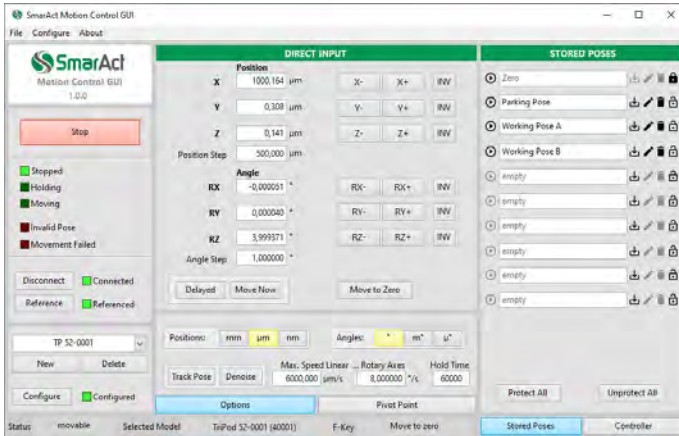
SmarAct products come bundled with different software tools to help you setup, configure and control your positioning systems. Depending on the specific product, the bundle includes one or more of the following tools and software development kits.

Precision Tool Commander (PTC)

The Precision Tool Commander offers a user-configurable interface for controlling SmarAct positioners and positioning systems. Functions for reading sensor data while moving in one and two dimensions are integrated, as well as automatic alignment of positioners while minimizing or maximizing a sensor signal. (For a list of supported sensors please contact SmarAct).



Positioning System Control Software



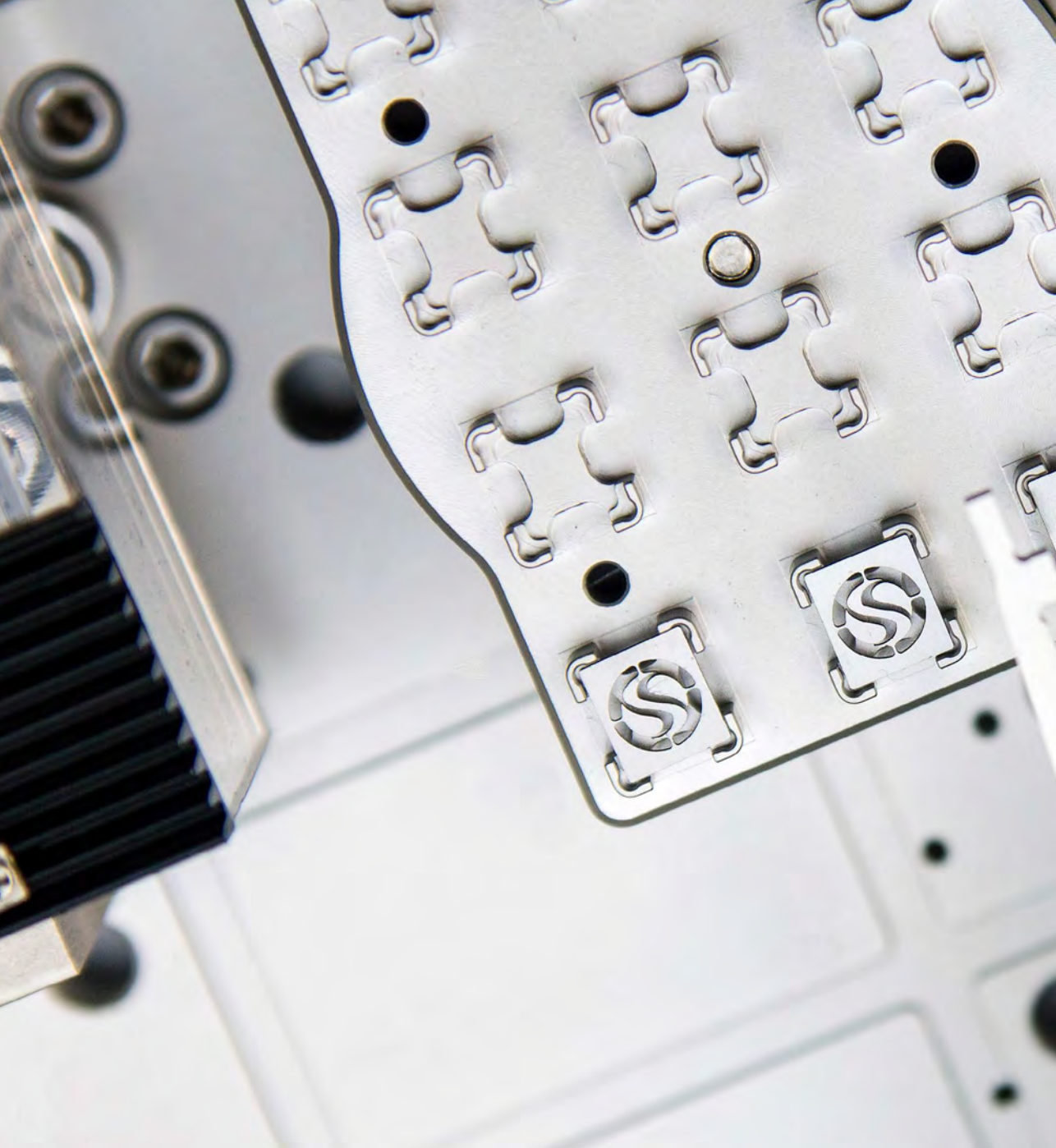
Positioning systems like SmarPods, TriPods, Tilt Stages and SmarGons can be directly controlled with a dedicated software tool that allows to store end effector poses and supports manual movements with a SmarAct Hand Controller.

Software Development Kits

SmarAct supplies different software development kits for easy and fast integration of SmarAct products into your control environment.

The software development kits include support for C/C++, Python® and LabVIEW™ and are available for Windows® and Linux.

Programming examples and detailed programming guides with function references are always included.



 **SmarAct** | automation



SmarAct Automation High Precision Automation Solutions

SmarAct Automation is your partner for high-precision alignment, handling and joining of components on a nano, micro and meso scale in all application areas where miniaturization becomes necessary for future development progress.

As part of the SmarAct group, SmarAct Automation benefits from 15 years of know-how in high-precision positioning technology.

SmarAct Automation develops fully or partly automated microassembly solutions for accurate positioning, gripping, aligning and mounting of small components.

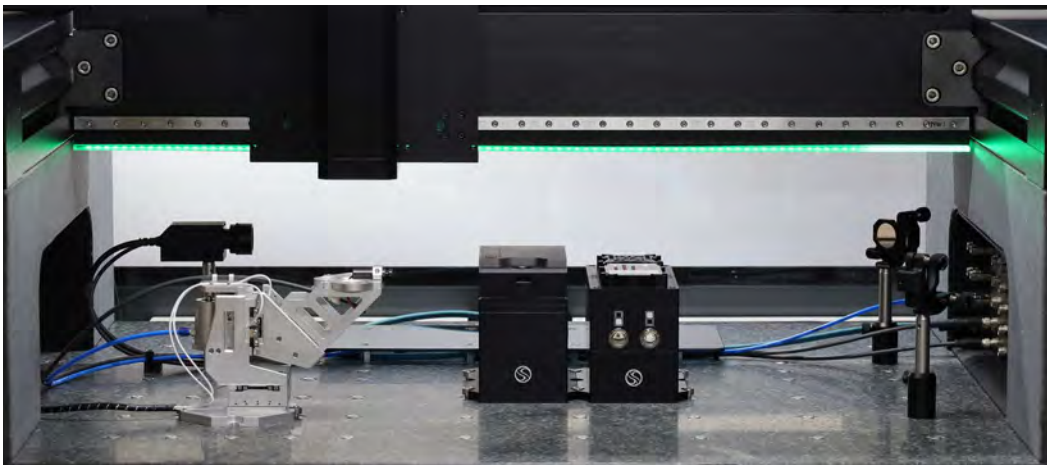
SmarAct Automation

Large Scale Automation



SmarAct Automation's P50 provides you with a secure, future-proof and reliable foundation to transfer your promising idea from the lab to successful serial production. Microassembly applications including the most demanding active alignment processes will offer you

the robust and secure framework your prospective research needs to lead the markets of the future on a large scale. To get an idea of the possibilities, please see page 180 and contact us.

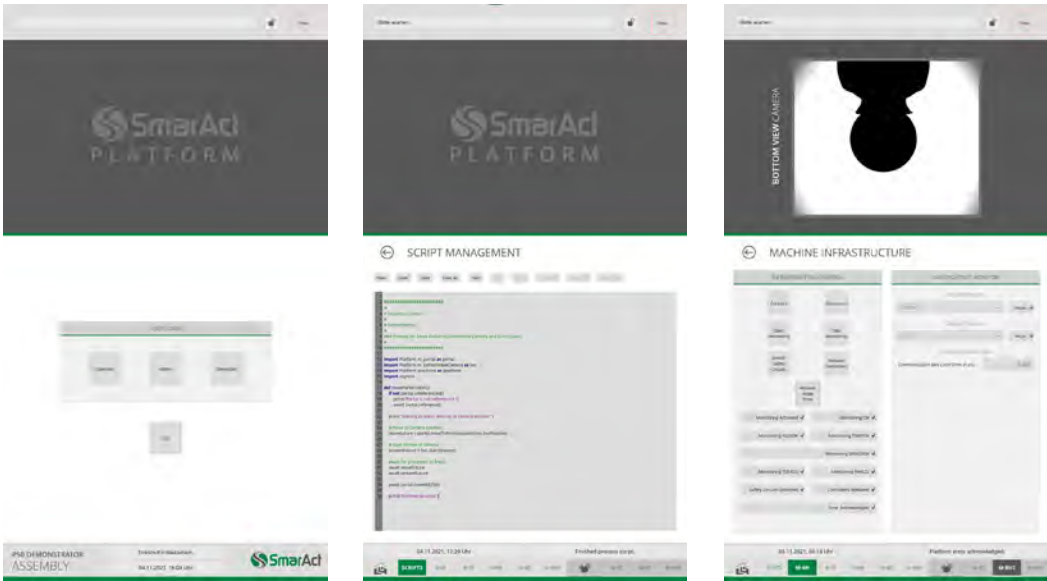




Future-Proof Modularity

Based on strict modularity, SmarAct Automation develops both partially and fully automated systems. The most advanced products from the entire SmarAct Group are used and combined with further state-of-the-art technology to provide precise, fast and reliable solutions. To complete this portfolio, SmarAct automation also offers process development, outsourcing manufacturing, and of course

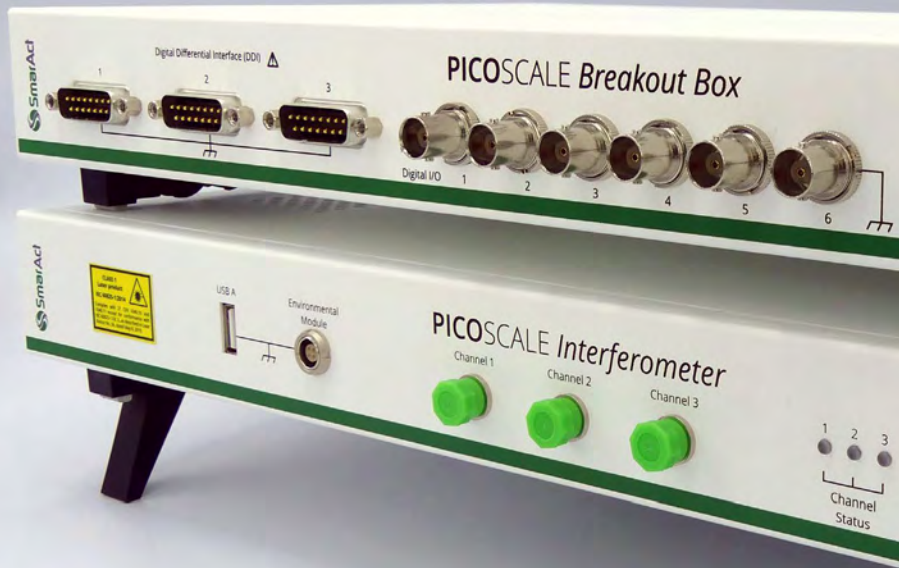
the mandatory maintenance and service packages around these products – for rapid development and future-proof integration of your microassembly processes into your production environment. The best-selling positioning systems such as the hexapod-like SmarPods and XYZ positioning systems from SmarAct can be expanded with versatile microgrippers and combined with sophisticated technical modules like SmarAct’s lens alignment module.



Customizable Operating Software

The modularity of your microautomation platform is not only reflected in the flexible use of various technical modules, but also in the software supplied. In addition to 100 % touch operability, the modular microautomation platform software offers an intuitive user guidance concept which adapts

perfectly to the user’s role. Interface options range from a basic operator GUI, guiding the user through processes with short and engaging video tutorials, to a fully featured developer interface, with the ability to load, customize and run Python® scripts through a scripting interface. This makes it possible to adapt your process on the fly.



 **SmarAct** | metrology

SmarAct Metrology High Precision Measurement Solutions



SmarAct Metrology develops sophisticated equipment to serve high accuracy positioning and metrology applications in research and industry within fields such as optics, semiconductors and life sciences.

Our broad product portfolio – from miniaturized interferometers for displacement measurements to powerful electrical nanoprobe for the characterization of smallest semiconductor technology nodes – is completed by turnkey scanning microscopes which can be used in vacuum, cryogenic or other harsh environments.

We maintain the complete production in house for a high level of customization so that we can always provide you the optimal individual or OEM solution. We also offer feasibility studies, measurement services and comprehensive support to accompany you along your projects.

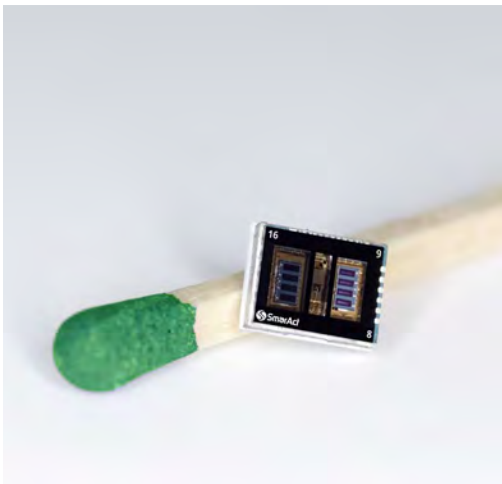
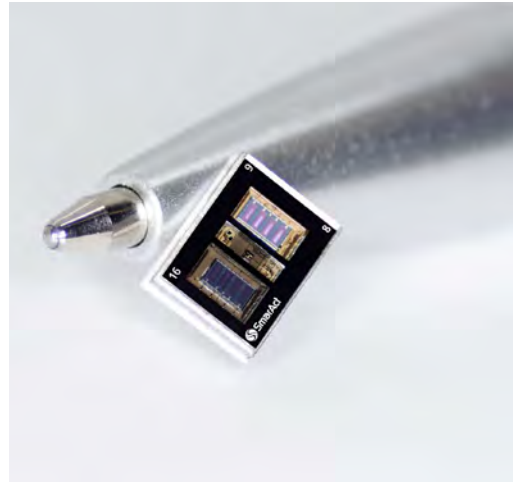
METIRIO® – What is it about?

SmarAct requires high-resolution and compact optical encoders for its own motion products. Suitable products were simply not to be found on the market. After many years of compromises, the decision was made to start an own development, which fulfills important requirements.

The result is the new optical encoder METIRIO®, which is presented here for the first time. METIRIO® is a new kind of optical encoder for closed-loop positioning with sub-nanometer resolution and extremely compact size. Thanks to the modular housing concept, the encoder can be tailored to customer requirements. METIRIO® is available as OEM component or as stand-alone optical encoder with diverse mounting options and various scales. Due to its low outgassing materials, low power consumption and high operating temperature range, METIRIO® encoders are suitable for various environments and applications.

Main Features

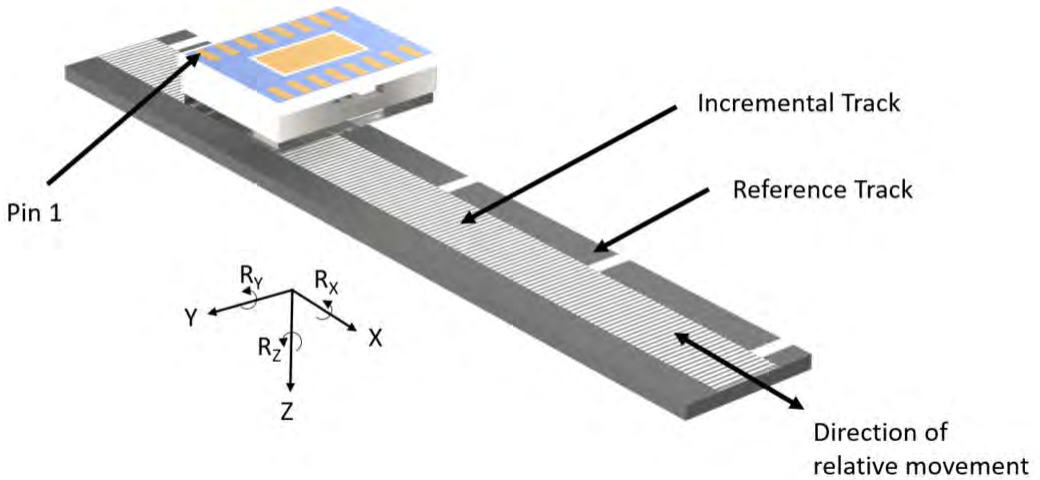
- High resolution (0.4 nm resolution at 1 m/s)
- Up to 10 m/s positioning speed
- Extremely small – worldwide unique (METIRIO® Read Head: 6.6 x 5.1 x 1.7 mm)
- No further components, such as capacitors or resistors, are needed
- Can be used for the detection of linear and rotational movements
- Power saving for low heat dissipation integrated
- Variable input voltage : 3.3 V to 5 V
- Digital interface modules with BiSS or ABZ interface are available
- Free GPI / GPO pins



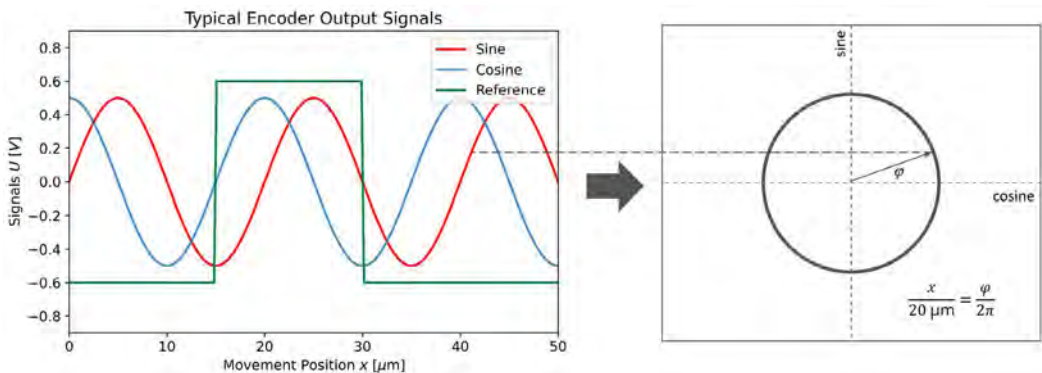
Various Environments

- Low outgassing ultra-high vacuum compatible
- 150°C baking possible
- Operating from 0°C to 80°C
- Non-magnetic materials
- IR center wavelength for scientific environments
- Rough environments with mechanical vibrations
- Low power consumption and low heat dissipation

METIRIO® Working Principle



An integrated light source illuminates a scale comprising an incremental grating with a 20 μm pitch and a track with reference marks for absolute positioning. The reflected light generates an interference pattern, which is detected by a diode array within the read head. A relative movement between the scale and the read head leads to analog sine and cosine signals as well as a TTL-shaped reference mark.



Modular Concept for METIRIO® Products

The METIRIO® product portfolio is consistently modular. Core product is the METIRIO® Read-Head, which can be used on its own, e.g. by OEM customers.

If requested, the read head can be purchased with additional functions and housings, so that a wide range of customer requirements can be met.

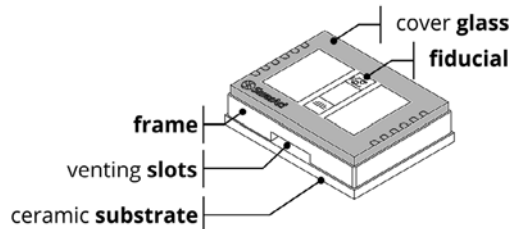
The choice between METIRIO® Read Head and other modular housing variants opens up a wide range of installation options for METIRIO® encoders:

- Direct soldering
- Soldering on PCB
- Mounting via screws
- Adhesive mounting

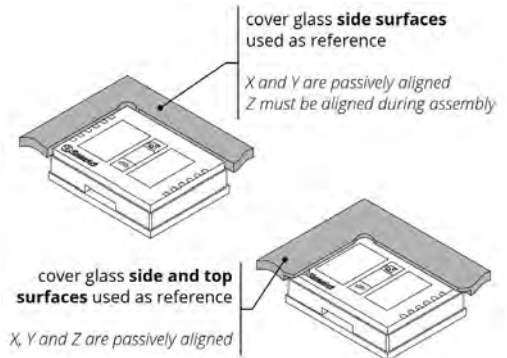


METIRIO® Read Head

The heart of the METIRIO® encoder product line is the basic METIRIO® Read Head. All optoelectronic parts are fully integrated in this SON-like package. Venting slots guarantee a quick evacuation in vacuum. Direct soldering onto a circuit board is also possible, since all connecting PINs are on the bottom side of the ceramic substrate.



The METIRIO® read head can be mounted in various ways to any mechanical housing. This gives high freedom operate the METIRIO® encoder. For opto-mechanical alignment, either the glass surface or the metal frame can be used.





Optomechanical Alignment

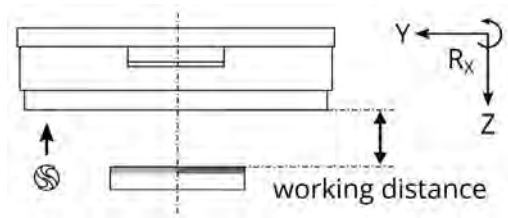
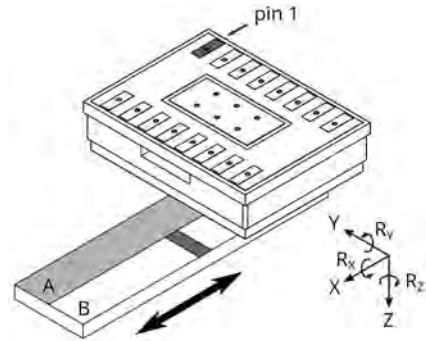
The METIRIO® encoder has comparatively large alignment tolerances, which makes integration quite easy.

The encoder is mounted to the fixed or moveable part of your motion system and the scale to the opposite side.

Depending on the mechanical constraints, one of three different working distances can be selected. The scale can be attached with adhesive and comprises two tracks for position measurement. One track for high-resolution incremental signals and the other track for reference mark detection.

For fixing the METIRIO® A1, it is possible to use M1.6 mounting threads.

- 1.2 mm working distance
- An evaluation-Kit available for quick and easy installation, diagnostics and adjustment



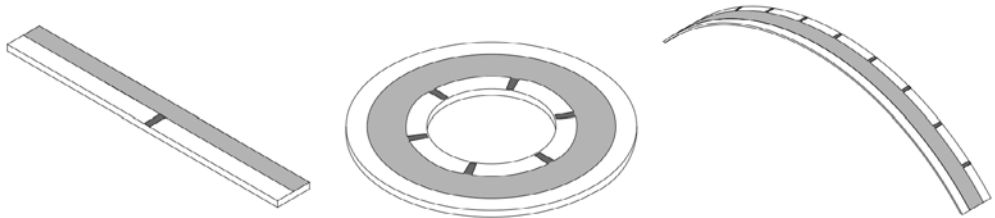
Optimum Mounting Position

The table shows the tolerances of the METIRIO® sensor in relation to the scale.

Axis	Nominal Position	Alignment Tolerance
X	direction of motion	
Y	0 mm	± 0.50 mm
Z	1.2 mm	± 0.15 mm
Roll R_x	0°	± 1.10°
Pitch R_y	0°	± 2.00°
Yaw R_z	0°	± 1.10°

METIRIO® Scales

Encoders of the METIRIO® family are compatible with a broad variety of reflective measuring scales. As long as the pitch equals 20 µm, the scales can be linear, circular or curved to convex shape. One read head can be used for all types of scales. SmarAct Metrology offers a variety of different scales:



METIRIO® is your versatile solution for linear, rotation and goniometer stages.

Glass with reflective chrome coating is well suited for METIRIO® encoder measuring scales. Each scale comprises an incremental track with high accuracy and an additional track carrying reference marks. Due to its diversity, METIRIO® will also work with different materials and with custom scale geometries tailored to your special application.

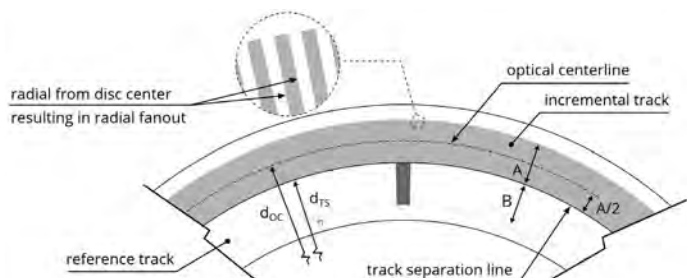
Scale Dimensions

We offer some scales with standard sizes available from stock. In addition, we also manufacture scales according to customers' requirements.

Available on request:

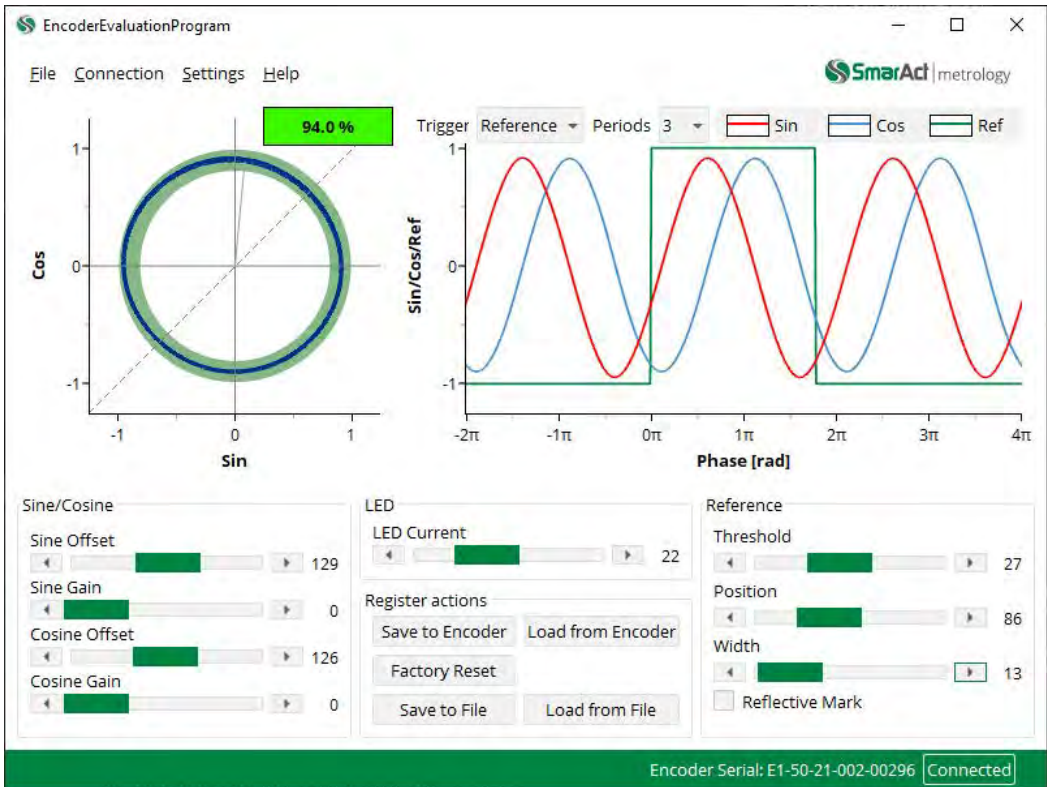
- Lengths up to 2 m
- Tailored rotational diameters (such as length, width, thickness, diameter)
- Flexible curved material
- Tailored dimensions
- Special reference mark codes

Optical Diameter d_{oc}	CPR: Counts per Revolution
13.0 mm	2048
22.9 mm	3600
38,2 mm	6000
63.6 mm	10000
95.5 mm	15000



Starter Kit & Configuration

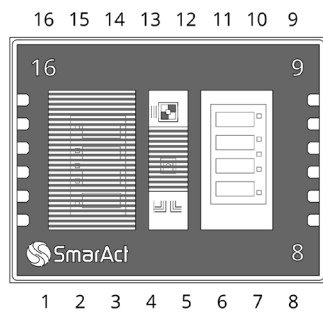
For the commissioning and setup of read heads and measurement systems the METIRIO® product line offers an evaluation kit. The evaluation kit consists of a slide and a suited mechanical interface for the read heads in order to detect signals from a scale when moving along. The evaluation kit is complemented by a graphical user interface and transmission electronics to set and retrieve operation parameters and signals.



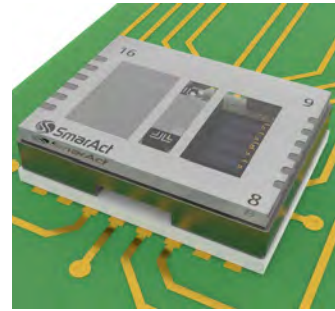
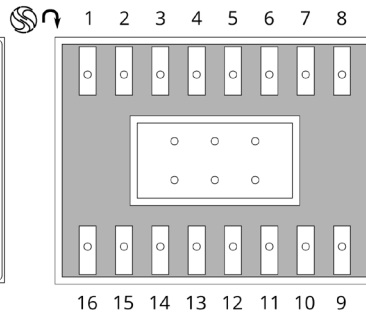
A METIRIO® sensor to be configured can be connected to the software so that appropriate settings can be found and stored in the METIRIO®'s memory. Afterwards the sensor can be connected with a motion controller to enable high precision closed loop control. For this the analog 1Vpp (Sin/Cos) signals can be used. Alternatively, with SmarAct's 14bit Interface module ABZ-Signals can be utilized.

Electrical Connections

Top View



Bottom View

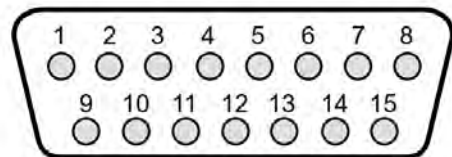


Pin Description							
01	02	03	04	05	06	07	08
$U_{\cos+}$ (out)	$U_{\cos-}$ (out)	$U_{\sin+}$ (out)	$U_{\sin-}$ (out)	V_{DD} (in)	U_{Ref+} (out)	U_{Ref-} (out)	GND
16	15	14	13	12	11	10	09
GND	d.n.c.	GPI (in)	GPO (out)	GND	PD (in)	SDA (i/o)	SCL (in)

A1 Connector (15-PIN D-SUB male)

The METIRIO® A1 comes with a D-SUB 15 male connector providing differential analog signals and the I2C-Interface Pins.

Additionally, an interpolation module can be attached to the METIRIO® A1 connector. This module provides typical ABZ-signals.



PIN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
METIRIO® A1	-	-	-	GND	$U_{\sin+}$	$U_{\cos+}$	U_{Ref+}	PD	-	SCL	SDA	$U_{\sin-}$	$U_{\cos-}$	U_{Ref-}	U_{DD}
Out (ABZ)	-	FAULT	CALIB	GND	A_z	B_z	Z_z	PD	-	SCL	SDA	A_z	B_z	Z_z	U_{DD}

PICOSCALE Metrology

Interferometry - System Components



The *PICOSCALE Interferometer* comes in a 19" rack housing.

Interferometer Controller

The *PICOSCALE Interferometer* is a powerful system for contact-free displacement measurements. The *PICOSCALE Interferometer* Controller contains a laser source and all necessary electronics to evaluate optical signals. These signals are generated in the sensor heads which are connected to the Controller via optical fibers. A beam splitter divides the laser beam into a reference and a measurement beam which are reflected off a reference mirror (typically inside the sensor head) and a target, respectively. Thanks to the Michelson principle, only very few considerations have to be made with respect to target reflectivity. Powerful firmware modules, convenient software and versatile accessories allow to easily integrate the *PICOSCALE Interferometer* Controller into new or already existing measurement setups.

Key Specifications

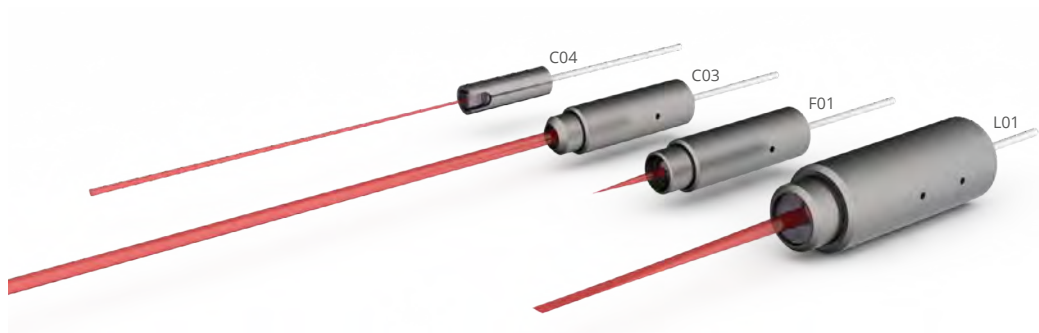
Channels	3
Maximum Target Velocity [m/s]	1
Maximum Working Distance [m]	5
Maximum Data Rate [MHz] ¹	10
Noise ²	1 pm/√Hz @ 1 kHz RMS: 190 pm (band 1 Hz ... 10 kHz)
Target Reflectivity ³ [%]	4 - 100
Laser Wavelength ⁴ [nm]	1550 Laser class 1 (eye-safe) Visible pilot laser to assist initial alignment
Measurement conditions	Ambient, ultra-high vacuum, cryogenics
Controller Chassis	48.2 x 32.6 x 6.0 cm, weight 3.7 kg

¹ Maximum bandwidth of position data is 2.9 MHz

² Working distance 20 mm, ambient conditions

³ Not crucial because of Michelson interferometer principle

⁴ Stabilized with gas absorption cell, NIST traceable



Interferometer Sensor Heads

- C03: Collimated measurement beam for large working distance
- C04: Compact sensor head for general purpose
- F04: Focused beam with high angular working range
- F01: Focused beam with high angular working range for small samples
- L01: Line-focused beam for runout measurements of cylindrical targets

	C03	C04	F04 ¹	F01 ¹	L01
Beam Geometry	Collimated		Focused		Line-focussed
Focal Distance [mm]	-		70	10	30
Beam Waist Diameter [μm]	1590	350	100	28	50 x 1590
Working Distance [mm]	13 ... 5000	13 ... 500	70 ± 10	10 ± 0.5	30 ± 10
Angular Working Range [°]	± 0.013	± 0.05	0.075	± 2	± 1.3 (along focused axis)
Environmental Compatibility	Air, HV, UHV	Air, HV, UHV	Air, HV, UHV		
Typical Targets	Retro-Reflector	Mirror		Small Samples	Cylindrical Samples
Dimensions [mm]	4 x 13	6 x 21	6 x 21		9 x 26

¹ Other focal lengths on request.



We are using a PICOSCALE line focusing sensor head to track the motion of a polished cylinder in our synchrotron beamline. This allows us to close a feedback loop and rotate the cylinder without eccentricity or - thanks to the large tolerances of the sensor heads - with a stub offset.

+++ National Synchrotron Radiation Research Center (NSRRC), Hsinchu, Taiwan

PICOSCALE Metrology

Interferometry Interfaces and Accessories



PICO SCALE Controller with accessory components: Breakout Box for convenient access to digital and analog signals.

Key Specifications

PICO SCALE Controller	USB und Ethernet	Data transfer to a user PC with up to 10 MHz data rate.
	Trigger Input	1 Trigger input at rear side
	SmarAct SI Interface	Direct link to SmarAct's motion controllers, e.g. MCS2
PICO SCALE Breakout Box	Serial Data	Serial data transmission of displacement or Calculation System data
	AQuadB	Incremental transmission of displacement or Calculation System data
	Analog Input	3 analog-to-digital converters with 16 bit resolution
	Analog Output	3 digital-to-analog converters with up to 16 bit resolution
	Trigger Input/ Output	6 digital inputs/outputs for synchronization with external devices
Additional Sensors	Environmental Module	Sensors for air pressure, temperature and relative humidity for compensation of changes in the refractive index of air
	Temperature Box	10 channels for resistive temperature sensors (PT1000)

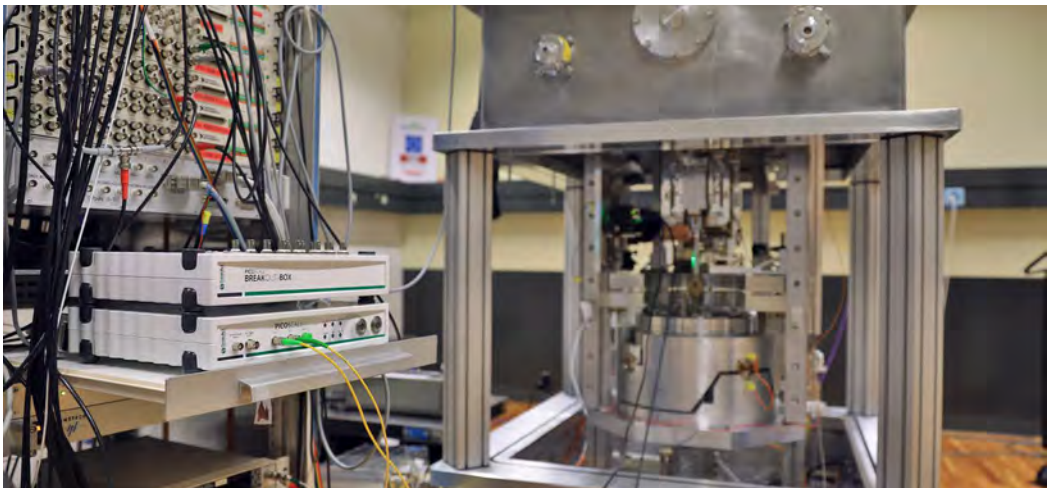
PICOSCALE Metrology Interferometry Interfaces and Accessories



Sensor Heads can be installed in standard optomechanical holders with convenient mounting accessories.



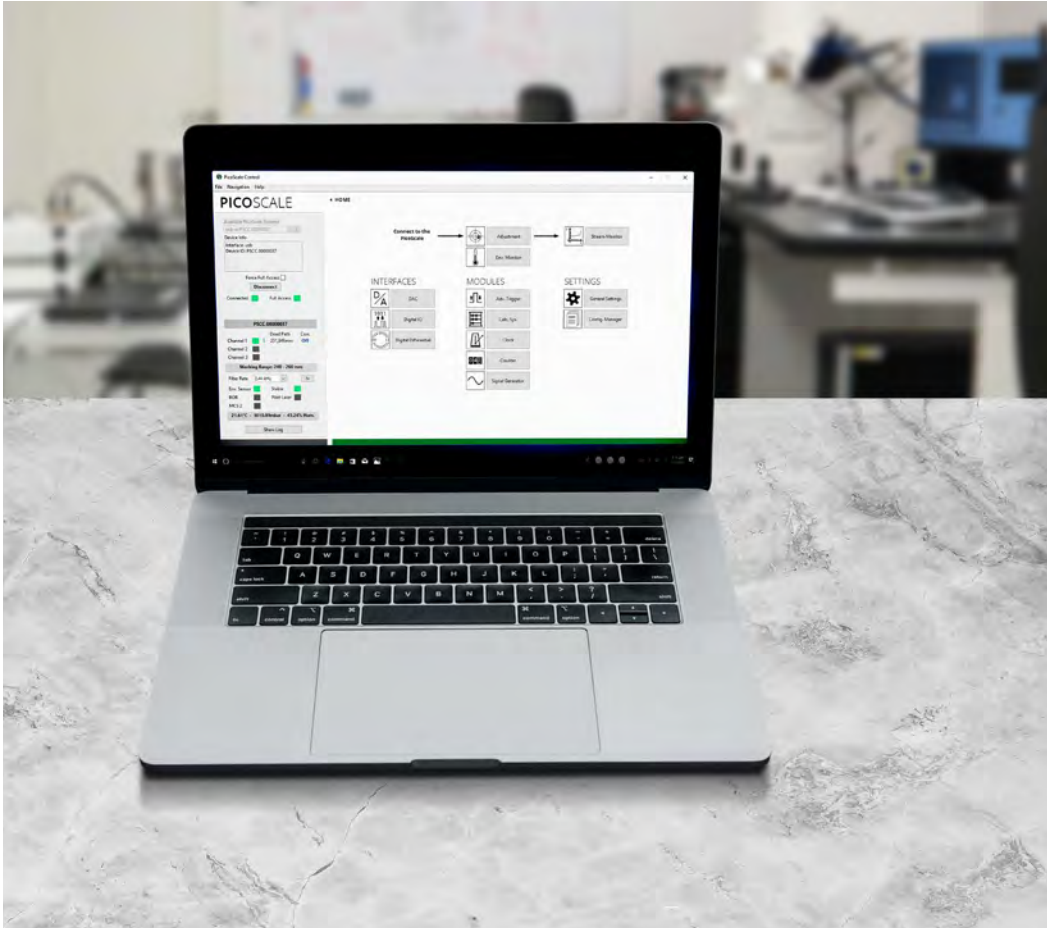
PICOSCALE Sensor Heads can be equipped with different tubings for enhanced robustness or specific environments.



The watt balance is comparing mechanical and electrical powers. In a first step, the mechanical force on a test mass in the earth's gravitational field is balanced with an electromagnetic force using a current-carrying coil. In a second step, the coil is moved through the magnetic field, which induces a voltage. The precise knowledge of the electrical, gravitational and dynamical properties allows to infer the mass in terms of natural constants only - instead of using the prototype mass in Paris. One requirement during the two phases of the experiment is the accurate determination of the position and angular orientation of the coil. This measurement is performed using the PICOSCALE Interferometer.

+++ Dr. Henri Baumann

+++ METAS, Federal Institute of Metrology, Berne, Switzerland



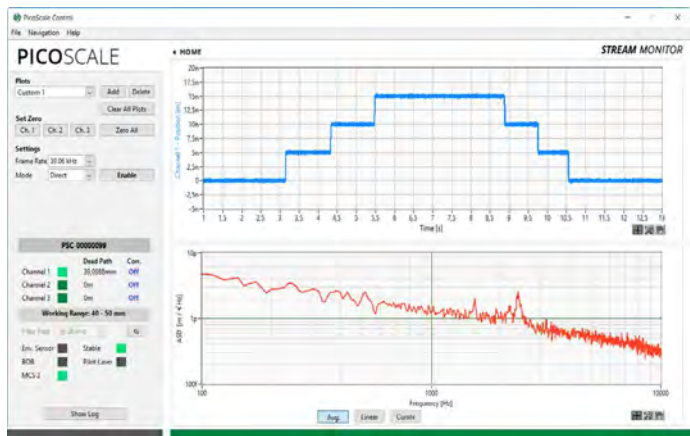
Key Features

- Multi-user ready: simultaneous interaction by a master user and an observer
- Software API with all drivers, libraries and programming examples for customized control software
 - LabVIEW™
 - C/C++
 - Python®
- All functions are combined in the convenient graphical user interface "PICOSCALE Control"



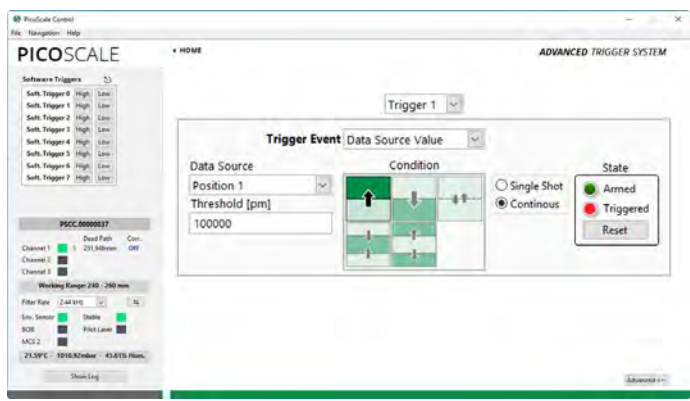
We are using the PICOSCALE as a position encoder for our motors and we will integrate the device in our HF facilities soon. We are very happy with the LabVIEW drivers that came with the system that allow us to combine our motion controllers with high precision displacement sensors in a single software tool.

+++ S. Martens
+++ University of Hamburg, Germany



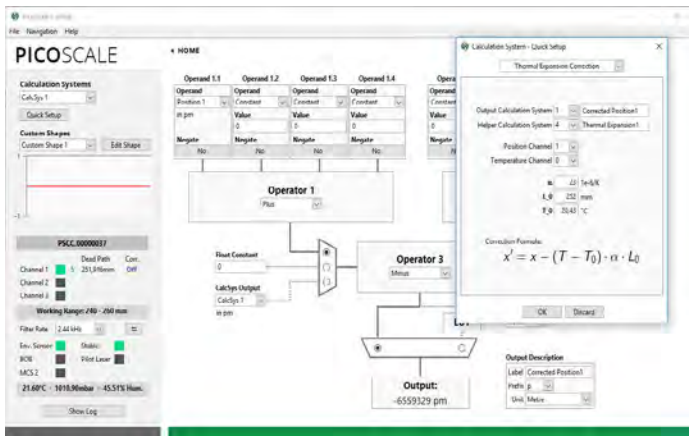
Stream Monitor

- User-friendly options to display and export data
- Spectral analysis using FFT functions
- Streaming data to a file
- Triggered streaming



Advanced Trigger System

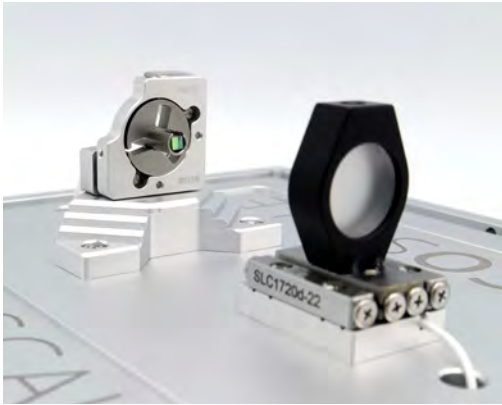
- Configuration of triggers for device synchronization
- Alerts in case of signal loss
- Event counter
- Clock input/output



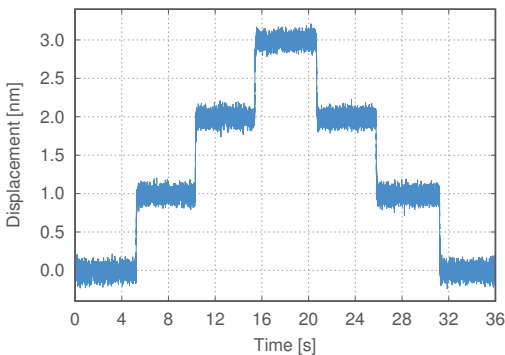
Calculation System

- Calculation of angles
- Thermal compensation
- Mapping of data with look-up tables
- Other user defined calculations

Closed-Loop Positioning

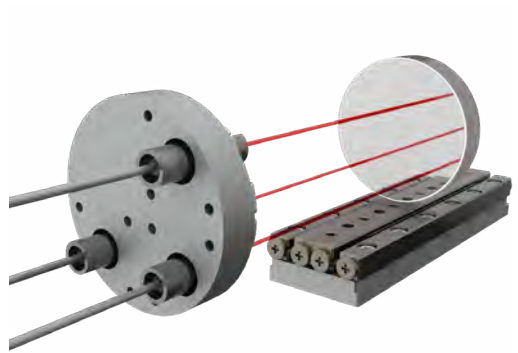


- Displacement encoding with measurement directly at the point of interest
- Low-latency feedback control with direct link between PICO SCALE and MCS2 motion controller

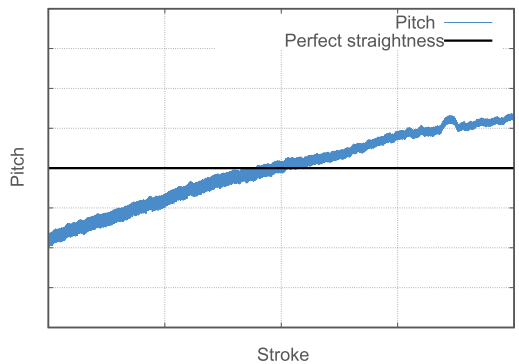


Closed-loop positioning in 1 nm steps using the PICO SCALE Interferometer with a direct link to SmarAct's motion controller MCS2.

Quality Control of Translation Stages



- Simultaneous measurement with 3 channels
- Compact and light sensor heads and targets
- Fast angle calculation in the system's FPGA
- Analysis of translation stages in 3D (z, Rx/yaw, Ry/pitch)
- Typical example of our measurement service, see page 22



Exemplary pitch measurement of a translation stage over its entire travel range.

Radial Runout Measurement of a Rotating Cylinder

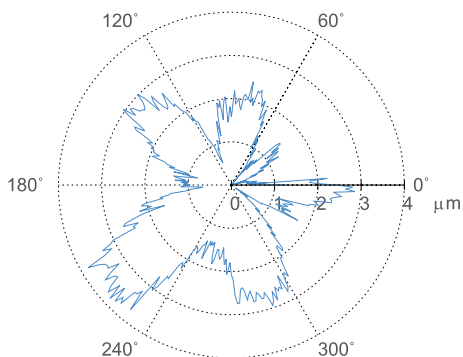


- Line focusing sensor heads aligned with rotating cylinder
- Measurements of radial runout and wobble
- Large tolerance to stub-offsets
- Sample positioning in synchrotron beamlines

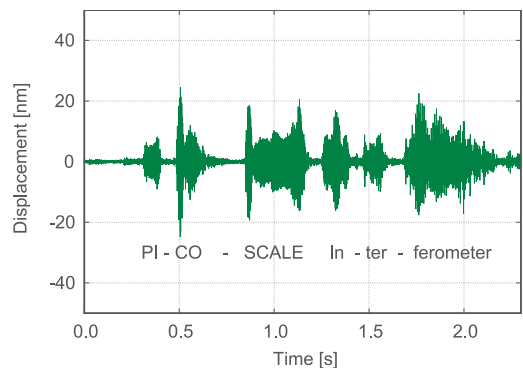
Measurement on a Glass Window



- Focusing sensor head directed at a glass window
- Direct streaming of position data into a file for subsequent data processing



Radial runout of a rotating cylinder. This information can be used to control the center of rotation.



Sound waves of a human voice excited the glass window and the displacement is measured with the PICO SCALE Interferometer.





Megapixel Modal Analysis of Small Samples with SmarAct's Scanning Vibrometer

Vibration measurements at up to one megapixel can be performed with SmarAct's scanning vibrometer, the solution for the modal analysis at high spatial and temporal resolution for samples such as MEMS, sensors and actuators.

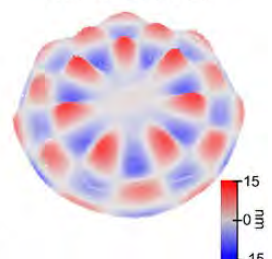
- Contactless measurement of vibrations with a resolution of under 1 μm
- Very high spectral resolution for out-of-plan vibration: 1Hz for 1s data recording and 0.1Hz for 10s data recording
- Spectral resolution for in-plane vibration: 1nm
- Up to 10 MHz sample rate to investigate vibrations up to 2.5 MHz
- Confocal optical design with an IR measurement laser (1550nm)
- Measurements possible through semi-transparent enclosures of plastic, glass and silicon
- Integrated confocal microscope with an optical resolution down to 2 μm
- Microscopy images are intrinsically aligned with vibration measurements
- Turn-key instrument complete with shaker stage and software

Microscopy image



20 mm

Vibrations at 354 kHz



Higher order bending modes can result in complex vibrational patterns. For a full modal analysis, the measurement laser of the PICO SCALE Vibrometer is scanned over the sample to record microscopy and vibration images simultaneously.

PicoScale Metrology

Vibrometry - System Components

1 Innovative Sensor Head

- Integrated Michelson interferometer
- Confocal optical design
- Various microscope objectives available down to 2 μm solution

2 Closed-Loop 3D Positioning System

- Closed-loop piezo positioners with nm resolution
- Scan range of 20 x 20 mm
- Highly reproducible positioning of laser beam
- Easy integration in custom setups through 1" post mount
- UHV compatible upon request
- 50 nm repeatability

3 Shaker Stage

- Mechanical excitation of samples by a fast piezo-based shaker stage
- High bandwidth of up to than 1.5 MHz
- Open-loop operation
- 15 cm^2 active area

Controller

- Class 1 laser coupled to the sensor head with fiber optics
- Configurable lock-in amplifier for the direct imaging of bending modes
- Vibration data can be processed in the time or frequency domain
- Outputs available for the electrical excitation of samples
- Synchronization with external function generators through trigger output





Software

The PICO SCALE *Vibrometer* is delivered with two programs that can be operated in parallel:

- Intuitive operation of the vibrometer with the Control software
- Extensive data analysis with the View software

Key Specifications

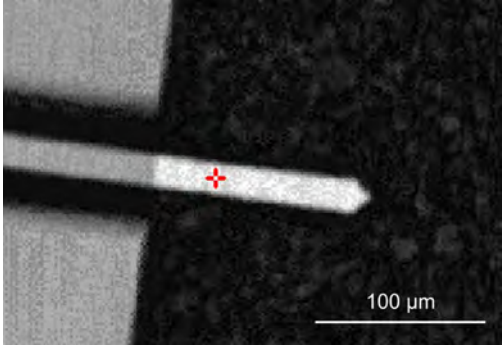
Vibrometry	Resolution ¹ [pm]	< 1
	Bandwidth ² [MHz]	2.5
	Maximum Sampling Range [MHz]	10
Microscopy	Optical Lateral Resolution ³ [µm]	2 - 7
	Optical Axial Resolution ³ [µm]	7 - 90
	Working Distance ³ [mm]	1.5 - 10
	Maximum Image Size [mm]	20 x 20
	Minimum Pixel Size [µm]	1
	Maximum Number of Pixels	1000 x 1000
Dimensions	Controller	2 units of each 33 x 27 x 7.2 cm (W x L x H), combined weight 7.6 kg
	Scanning Stage	5.5 x 11.0 x 7.5 cm (W x L x H), weight 0.25 kg
	Instrument Mount	Granite stone 15 x 20 x 4 cm (W x L x H) with stainless steel post 2.5 x 15 cm (Ø x H), combined weight 4.3 kg
	Shaker Stage	8 x 1.5 cm (Ø x H), weight 0.5 kg

¹ When analyzing displacements in the frequency domain

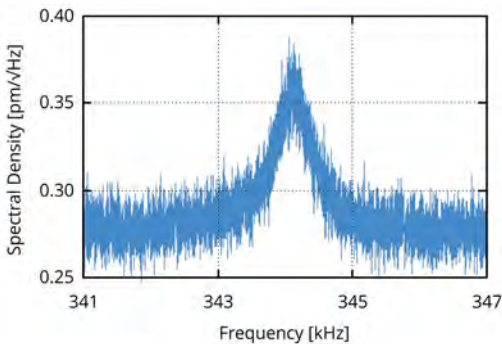
² Sampling rate is 10 MHz

³ Depending on the selected sensor head

Single Point Measurements

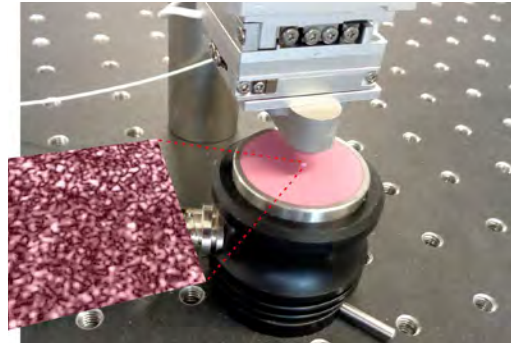


- Measuring out-of-plane vibrations with interferometry
- Easy selection of measurement points with integrated optical microscope
- High resolution and bandwidth

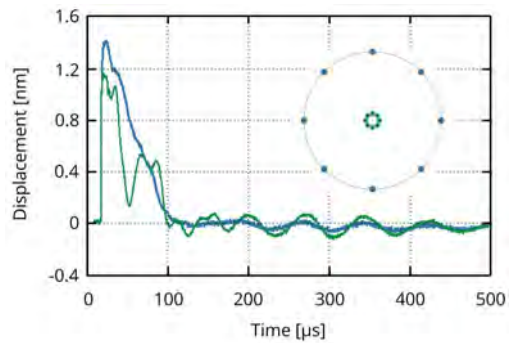


The amplitude spectrum of a micro cantilever was measured at the indicated position. Although the cantilever was not actively excited, the high resolution of the interferometric measurements still allows to detect the thermal fluctuations, in this case 0.36 pm at 344 kHz.

Characterizing Ultrasonic Transducers According to the Norm ISO 24543



- Measuring sub-nm motion at multiple predefined points
- Sample excitation with external arbitrary waveform generator



Measuring motion at a circular array of points on the surface of an ultrasonic transducer. The graphs show the averaged response from all measurements performed at 1.3 mm (green) and 10 mm (blue) from the transducer center. We thank Vallen Systeme GmbH for their support with this application example.

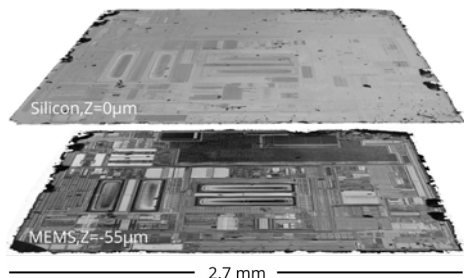


The PicoScale Vibrometer with its capabilities to perform megapixel modal analysis and confocal IR microscopy is an ideal tool for our MEMS development activities.

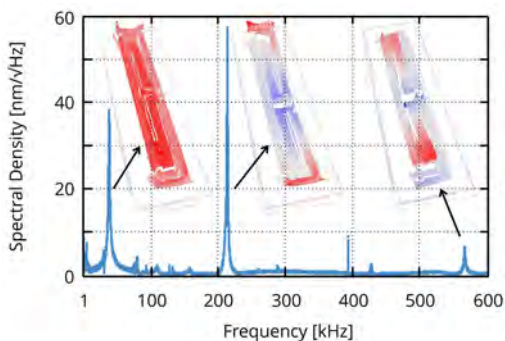
+++ Dr. J. Volk

+++ Nanosensors Lab in Budapest, Centre of Energy Research

Measuring MEMS through Silicon

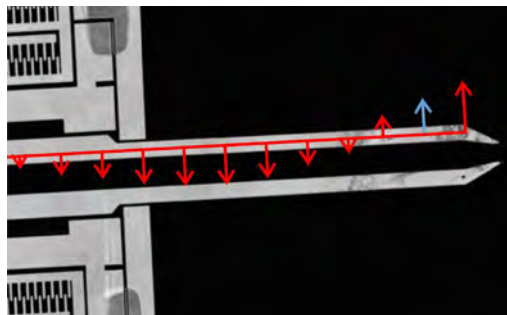


- Selective imaging of layers with infrared confocal microscopy
- Measuring through semi-transparent materials such as glass and silicon
- Semi-transparent structures themselves can still be measured when in focus

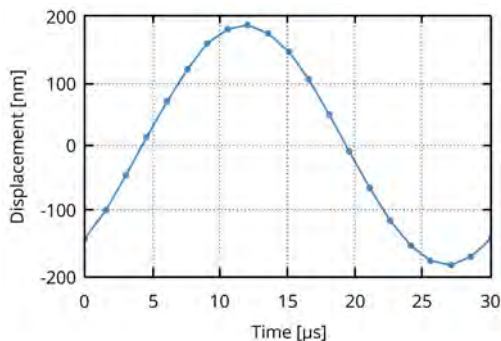


Measuring vibrations of MEMS through a packaging of silicon is made possible by confocal imaging with an IR light source. We thank InvenSense, a TDK Group Company, for their support with this application example.

Imaging Lateral Vibrations



- In-plane motion is imaged by recording a sequence of microscopy images that span exactly one vibration cycle (conceptually similar to stroboscopic imaging)
- In plane vibrations down to 10 nm can be extracted through optical flow algorithms



Lateral vibrations are measured by recording a sequence of microscopy images. Of any moving part within the images the motion can be quantified with a tracking routine. Although this method is based on microscopy, and not on interferometry, the resolution is not limited by optical diffraction and can be as good as a few nm.



For the development of our novel MEMS vibrometer, the ability to inspect and understand the dynamic behavior of the sensor's inertial core system is a crucial analysis method. With the help of the provided PicoScale-based vibration analysis and their expertise in metrology, SmarAct strongly contributed to the sensor development. For future research, we are planning to keep up the excellent collaboration with SmarAct.

+++ J. N. Haus
+++ Braunschweig University of Technology, Germany



Measurement Services

- Simplify your development process by outsourcing specific measurement tasks
- Results are reported according to established or customer defined standards.
- Benefit from our long-standing expertise in displacement and vibration measurements
- Get faster approval for measurement services as opposed to an investment in technology

Rental Services

- **PICOSCALE** Interferometers and Vibrometers can be rented on a weekly or monthly basis
- Direct support from SmarAct's application engineers
- Benefit from the latest equipment
- Evaluate the impact of new measurement capabilities prior to an investment decision

Take the next step

Our measurement and rental services can help to optimize your development process but also to solve a one-off problem that limits the performance of your product. Please contact us to discuss your requirements and plan a pilot study today.


Typical Customer Applications

Characterizing vibrational modes with laser scanning vibrometry.

- MEMS
- Wire bonds
- Voice coil motors
- Ultrasonic transducers
- Micro-loudspeakers
- Hearing aids
- Acoustofluidic devices
- Noise source identification for microscopy (AFM, EM)

Multi-dimensional analysis of motion at unsurpassed resolution by parallel interferometric displacement measurements.

- Calibration and validation of positioning and motion systems
- Repeatability and accuracy
- Thermal stability
- Tip/tilt of target during translation
- Radial run-out of a rotating system

Interface (DDI) 

PICOSCALE Breakout Box



USB A
Environmental Module

PICOSCALE Interferometer



1 2 3
Channel Status
Laser Status

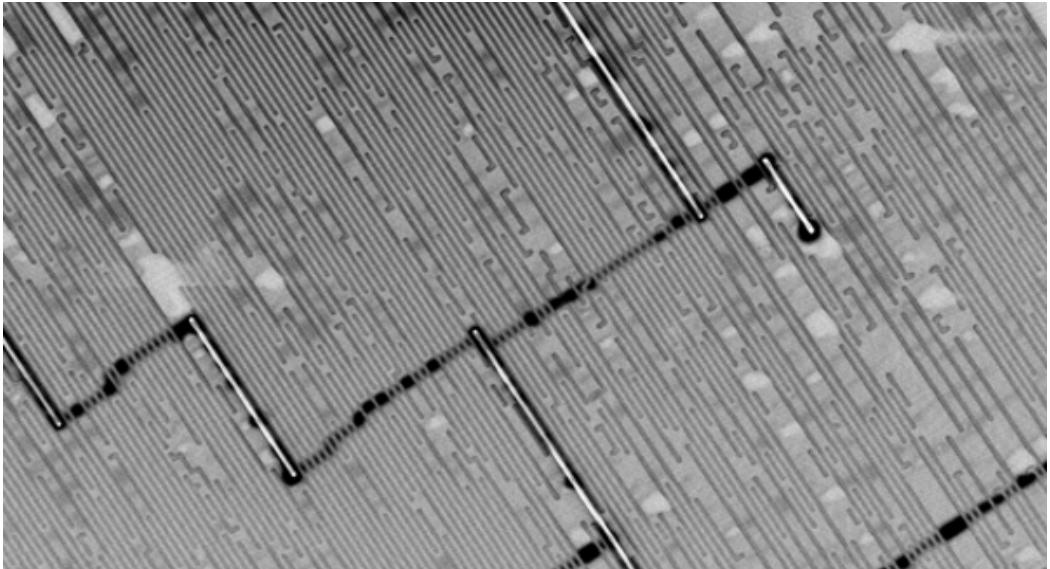
SMARPROBE

Electrical Probing



The SMARPROBE motion system consists of up to eight manipulators with integrated probe holders and an additional sample stage, each based on the latest SmarAct positioning technology. The motion system is closed-loop controlled, allowing active position holding with 1 nm accuracy on a sample

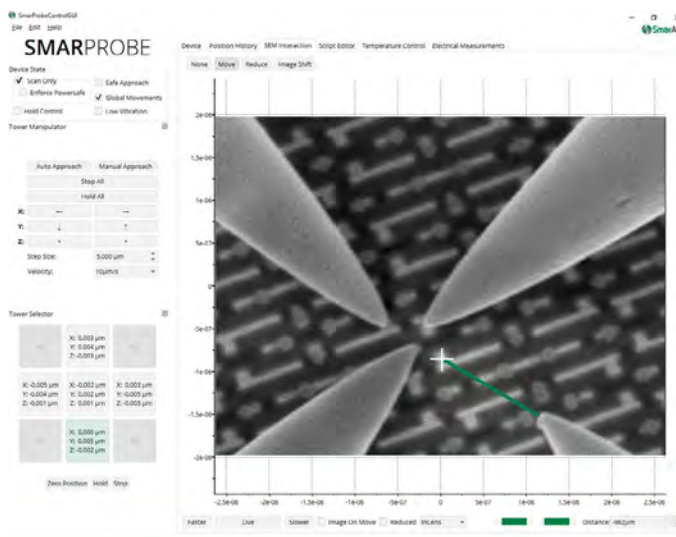
area of 25 x 25 mm. The active temperature control of the nanoprobe makes it possible to achieve stable electrical contacting of multiple probe tips at the point-of-interest, such as a single transistors of the 5-nanometer technology node, even under thermally non-stable environments.



Analyzing metal line network using EBAC.

Thank to closed-loop positioning, the probes and the sample can be navigated automatically via absolute values (CAD) or intuitively via “point-and-click” within the microscope image. To simplify the landing of the probes on the samples surface, the unique “Advanced Probe Holder” allows automatic landing on any material, regardless of conductivity. Time-consuming procedures such as probe alignment directly at the point of interest are automated within the SmarProbe software.

The software can control a parameter analyser to implement electrical characterisation routines. In addition, the probe holder has an integrated low-noise current amplifier for ultra-fast and low-noise measurements of currents, which can be used e.g. for electron beam techniques like EBIC, EBAC or EBIRCH. All motion and measurement sequences can be automated and customized using Python scripting.



Exceptional performance

Fully encoded with 1 nm resolution

Active position holding

Large scan-range and low thermal drift

Large area probing on full 25 x 25 mm

Low-noise high-speed EBAC/EBIC imaging

Non-magnetic materials to enable very low acceleration voltages

Low thermal drift to probe the latest technology nodes

Efficient and easy

All-in-one user interface (Nanoprober, SEM, Parameter Analyzer)

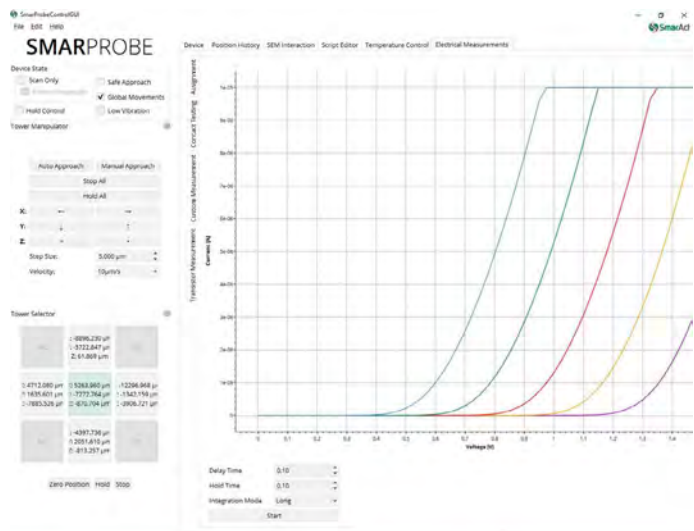
Automatic landing and alignment of all probes

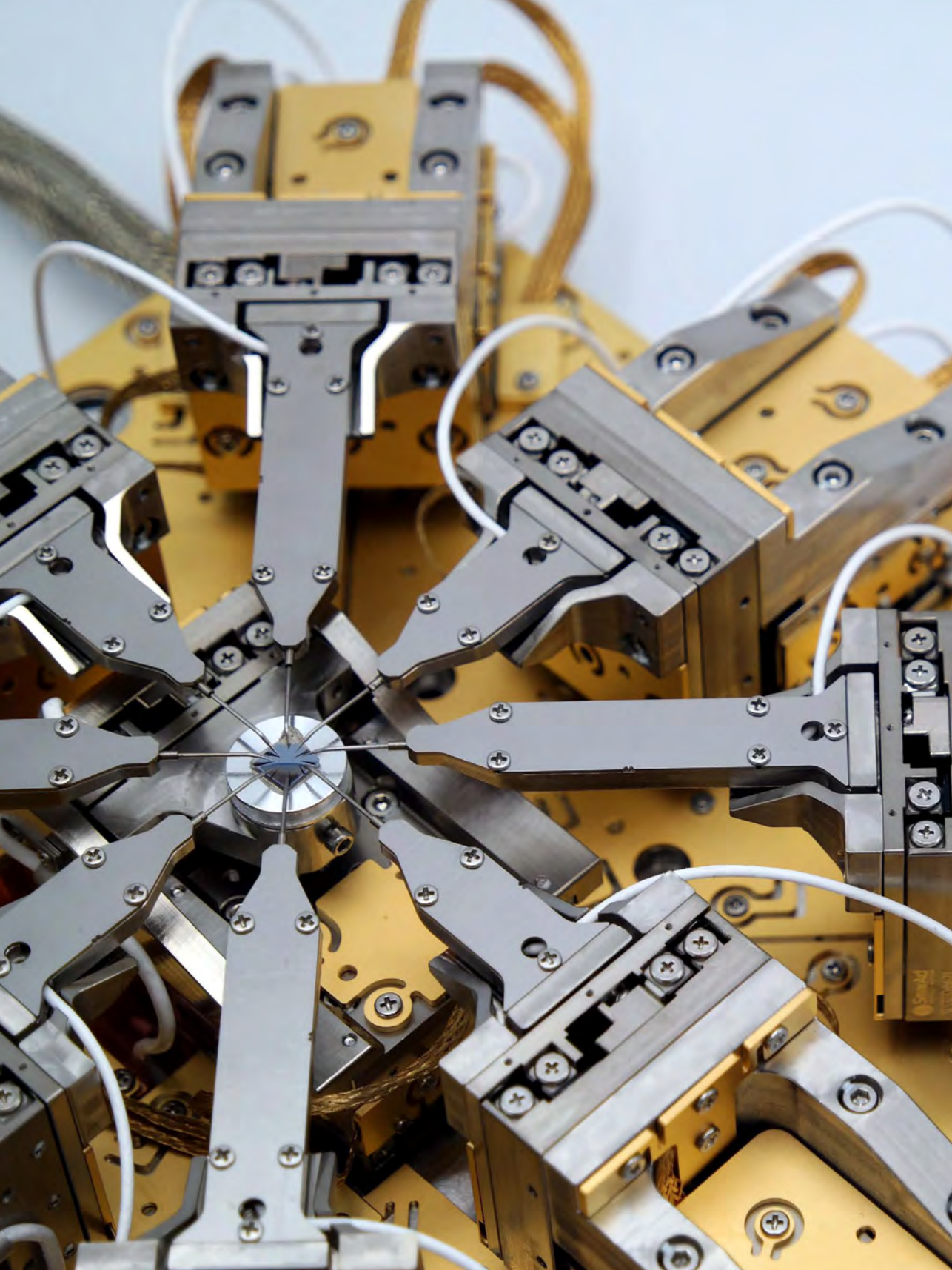
“Point & Click” navigation within the SEM image

Group movements and “Step & Repeat”

CAD navigation for sample and probes

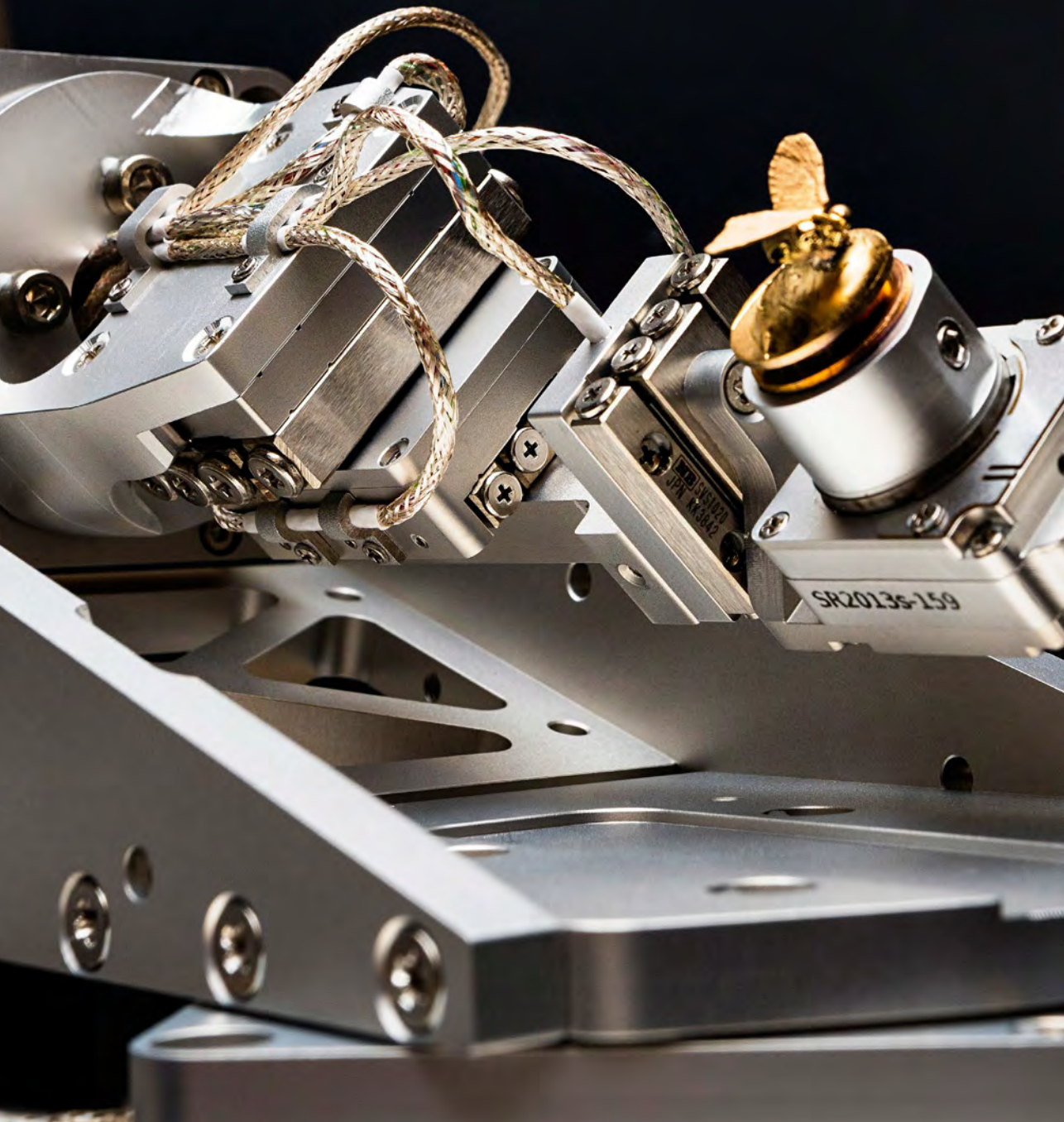
Guided workflows for most challenging probing tasks





Manipulators	
Number of Manipulators	2, 4, 6 or 8
Probe Mount	0.25 mm Diameter Tungsten Probes
Maximum Measurement Frequency [MHz]	100
Scan-Range in XYZ [μm]	> 10
Leakage Current at 10 V [pA]	< 1 (with Coax, optionally with Triax available)
Min. SEM Working Distance [mm]	2
Sample Stage	
Scan-Range in XYZ [μm]	4
Sample Mounting	Up to 4 SEM stubs at once
General Specifications	
Size SP8, W x L x H [mm]	187 x 187 x 56
Size SP6, W x L x H [mm]	183 x 183 x 56
Size SP4, W x L x H [mm]	156 x 156 x 56
Motion System	XYZ Closed-loop, Sample Stage and Manipulators
Operating Environment	HV (10–7 mbar), Ambient Conditions
Cleaning	Plasma Cleaning Compatible
Relative Drift between Probe and Sample [nm/min]	< 1
Thermalization Time in Vacuum [h]	< 1
Options	
EBIC/EBAC/Ebirc amplifier	In-situ amplifier for lowest imaging noise
User defined automation	Python scripting
Etching station	10 min for 3 probes with tip radius
CAD navigation	Compatible with open-source layout viewer

Markets and Applications



This SEM sample stage with eight degrees of freedom consists of several SLC linear stages combined with two rotation stages allowing an eucentric rotation of the specimen.



The development and manufacturing of devices in the sector of high precision technology and the supply of our customers with innovative solutions for most demanding applications is our mission at SmarAct.

Regardless of whether your project requires only a minor adaption of a single stage or if a complex multi-axis positioning system has to explicitly meet your requirements – solving your specific positioning, micro-automation or measurement tasks inspires us every day and is our greatest motivation.

To do so, we have established teams with particular expertise in **Semicon & Photonics**, **High Energy Research Facilities**, **Light Microscopy & Life Science**, and **Microscopy & Materials Science**.

We dedicate this chapter of the catalog to our customers and their projects and solutions we have developed for and with our customers by presenting some of our joint projects on the following pages.

The Art of SEM Imaging

for Stefan Diller, Scientific Photograph, Würzburg, Germany

The Leipzig Panometer displays changing visual panoramas inside a former gasometer and was created by the Austrian-born artist Yadegar Asisi, who also named the building as a portmanteau of “panorama” and “gasometer”. Each panorama is accompanied by a thematic exhibition. From January 26th 2019 the exhibition “Carolus Garden” is shown. The exhibition takes visitors on a journey to the foreign world of the microcosm. From the perspective of a grain of pollen, visitors can observe a giant bee as it pollinates the flower and discover the universe behind a flower calyx. A familiar world unfolds as if under a gigantic microscope. The depicted world around is one hundred times its real size.

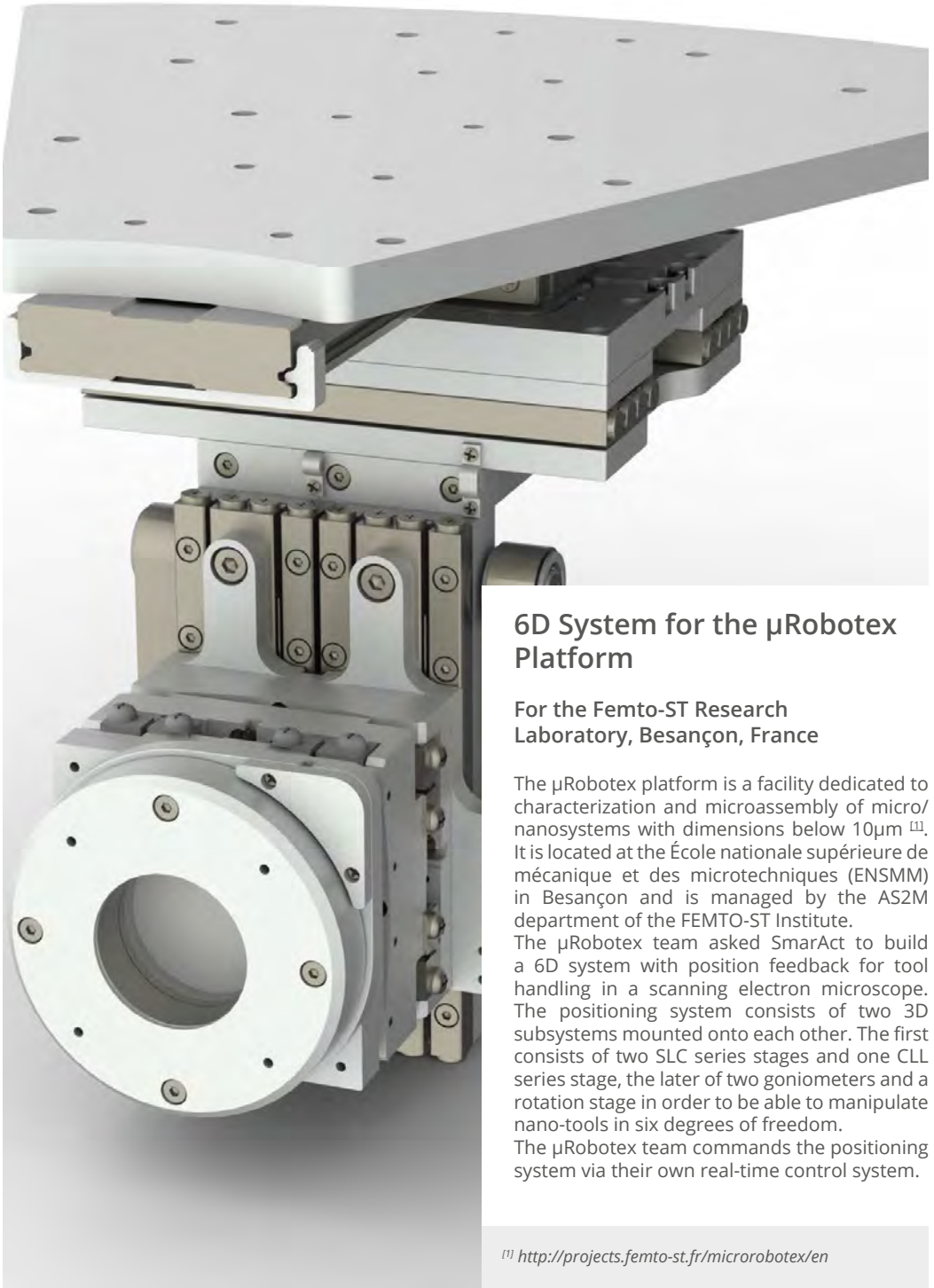
The scientific photographer Stefan Diller took part in this by generating scanning electron microscopy (SEM) images of the bee and the chamomile blossom: “A technically very complex project, which in the end was perfectly presented in the Rotunda of the Panometer. The honey bee sitting on the chamomile blossom is probably the largest printed image derived from scanning electron microscopy data”, says Diller.

It is one of the world’s largest 360° cycloramas with a dimension of 110 x 32 m sublimation printed on thirty-seven polyester sheets. The image data used for these gigantic prints needed to be extremely detailed. Therefore, conventional macro photography cannot be used because the image resolution is simply not high enough. Instead, Stefan Diller used a scanning electron microscope (TESCAN MIRA3 FE-SEM) equipped with a multi detector setup and a SmarAct SEM stage.

SmarAct’s eight-axis SEM piezo stage was used to position the motifs precisely under the SEM’s objective lens while recording the many tiles necessary to create the stitched image. The stage offers three axes of rotation and five translational degrees of freedom to position the SEM sample with nanometer precision under the electron lens.







6D System for the μ Robotex Platform

For the Femto-ST Research Laboratory, Besançon, France

The μ Robotex platform is a facility dedicated to characterization and microassembly of micro/nanosystems with dimensions below $10\mu\text{m}$ ^[1]. It is located at the École nationale supérieure de mécanique et des microtechniques (ENSMM) in Besançon and is managed by the AS2M department of the FEMTO-ST Institute.

The μ Robotex team asked SmarAct to build a 6D system with position feedback for tool handling in a scanning electron microscope. The positioning system consists of two 3D subsystems mounted onto each other. The first consists of two SLC series stages and one CLL series stage, the later of two goniometers and a rotation stage in order to be able to manipulate nano-tools in six degrees of freedom.

The μ Robotex team commands the positioning system via their own real-time control system.

^[1] <http://projects.femto-st.fr/microrobotex/en>

High Precision Lens Alignment for Macromolecular Crystallography

At the X10SA Beamline, Swiss Light Source (CLS) at the Paul Scherrer Institut (PSI), Switzerland

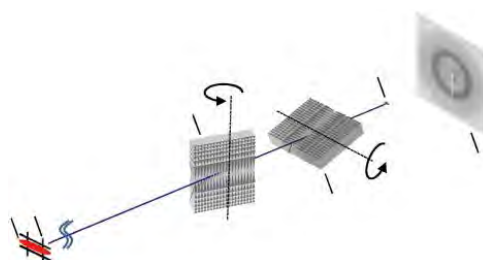
Researchers of the PSI have developed an innovative solution based on a two-stage demagnification microfocus module for hard X-rays based on a hybrid reflective-diffractive approach^[1].

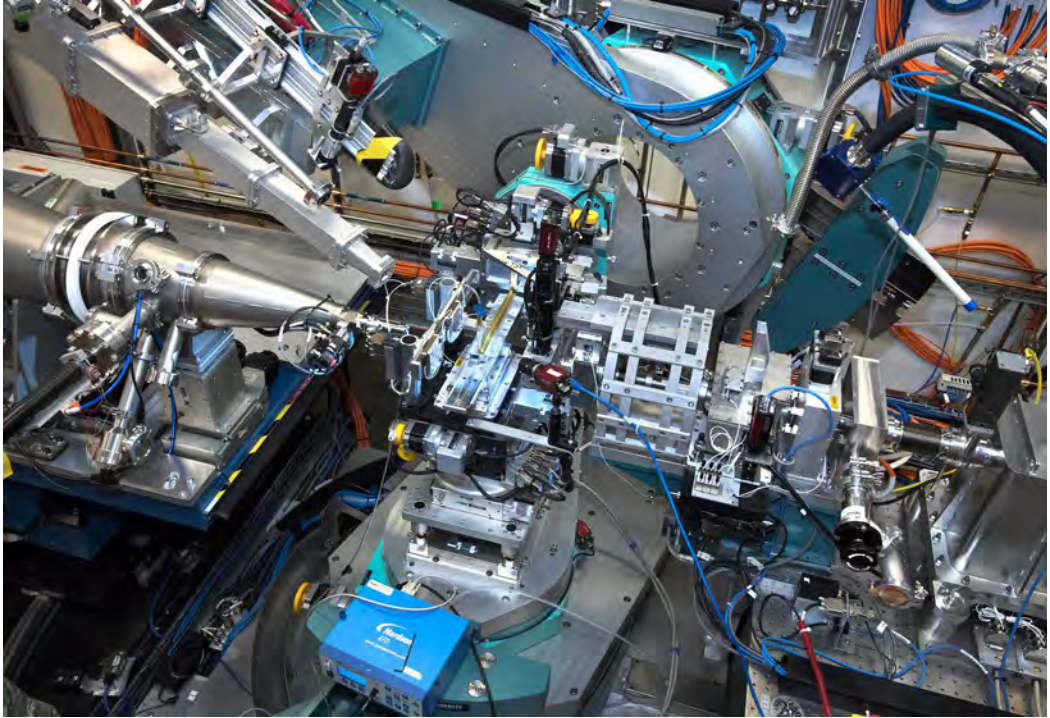
A prefocusing of the undulator source of the X10SA beamline at the Swiss Light Source (CLS) is achieved with a pair of reflective and diffractive optics which creates a secondary source. A second demagnification stage refocuses the beam to the sample position utilizing a pair of high-efficiency kinoform diffractive lenses.

Two **SMARPODS** (see page 77) are used to precisely align the kinoform lenses within the X-ray beam. Per dimension, three chips containing four lenses each are mounted on top of two of the hexapod-like **SMARPODS**. Due to the long travel ranges of these customized positioning systems an array of lenses can be mounted at once, whereas each lens combination can be positioned and precisely aligned in the X-ray beam. All mechanical units including the lenses are placed in a high-vacuum chamber. Thus, a single lens can be selected and aligned in all six degrees of freedom with nanometer precision in high-vacuum. Both **SMARPODS** glide on a 1 meter CLLV42 rail for coarse positioning along the X-ray axis.

Macromolecular crystallography often requires focused high-intensity X-ray beams for solving challenging protein structures from micrometer-sized crystals using synchrotron light sources. The design of optical focusing schemes for hard X-rays showing high efficiency and flexibility in beam size is therefore continuously pursued.

^[1] High-intensity x-ray microbeam for molecular crystallography using silicon kinoform diffractive lenses, Maxime Lebugle et al., *Applied Optics*, Vol. 57, No. 30, 20 October 2018, doi: 10.1364/AO.57.009032





3D Printer Stage for Fundamental Research in Additive Manufacturing

At the CHX Beamline, National Synchrotron Light Source II (NCLS-II), Brookhaven National Laboratory, Upton, New York, USA

With new opportunities and challenges from additive manufacturing, novel characterization approaches are needed to realize reliable and industry-transferable material systems and processes.^[1]

Different additive manufacturing capabilities have been co-developed and implemented on three beamlines at NCLS-II.

A printing platform was developed and implemented at the CHX beamline for operando studies of structure and dynamics during Continuous-flow Direct Writing (CDW) processing. To avoid artifacts in XPCS measurements and preserve spatial resolution in microbeam experiments, eliminating vibrations during the printing process was an important design goal.^[1] SmarAct has developed the XYZ system for positioning of the printbed. It is based on a serial

combination of linear stages of the SLC and CLL series. The gantry that is being used to position the printheads makes use of one of the key features of the CLL product series, which is its unique ability to use several piezo-driven carriages on a single rail. Here this feature is being used to simultaneously hold two different printheads, one of which can be also equipped with a Y-translation. This is realized by an CLS-3232 linear stage that can be mounted on top of one of the carriages. See the latest article of the group for more details about the experimental setup and first results^[1].



^[1] L. Wiegart, G. S. Doerk, M. Fukuto, S. Lee, R. Li, G. Marom, M. M. Noack, C. O. Osuji, M. H. Rafailovich, J. A. Sethian, Y. Shmueli, M. Torres Arango, K. Toth, K. G. Yager & R. Pindak (2019) Instrumentation for In situ/Operando X-ray Scattering Studies of Polymer Additive Manufacturing Processes, *Synchrotron Radiation News*, 32:2, 20-27, DOI: 10.1080/08940886.2019.1582285



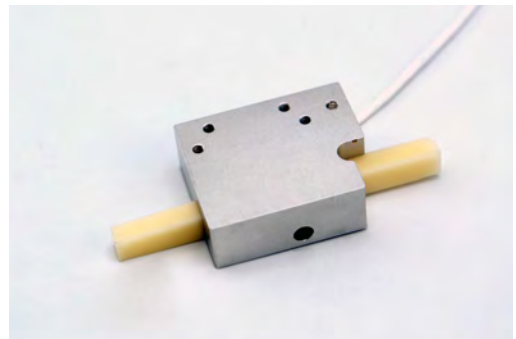
Cryo Compatible Positioners to Align the Optics Combining the Images of the Individual Telescopes

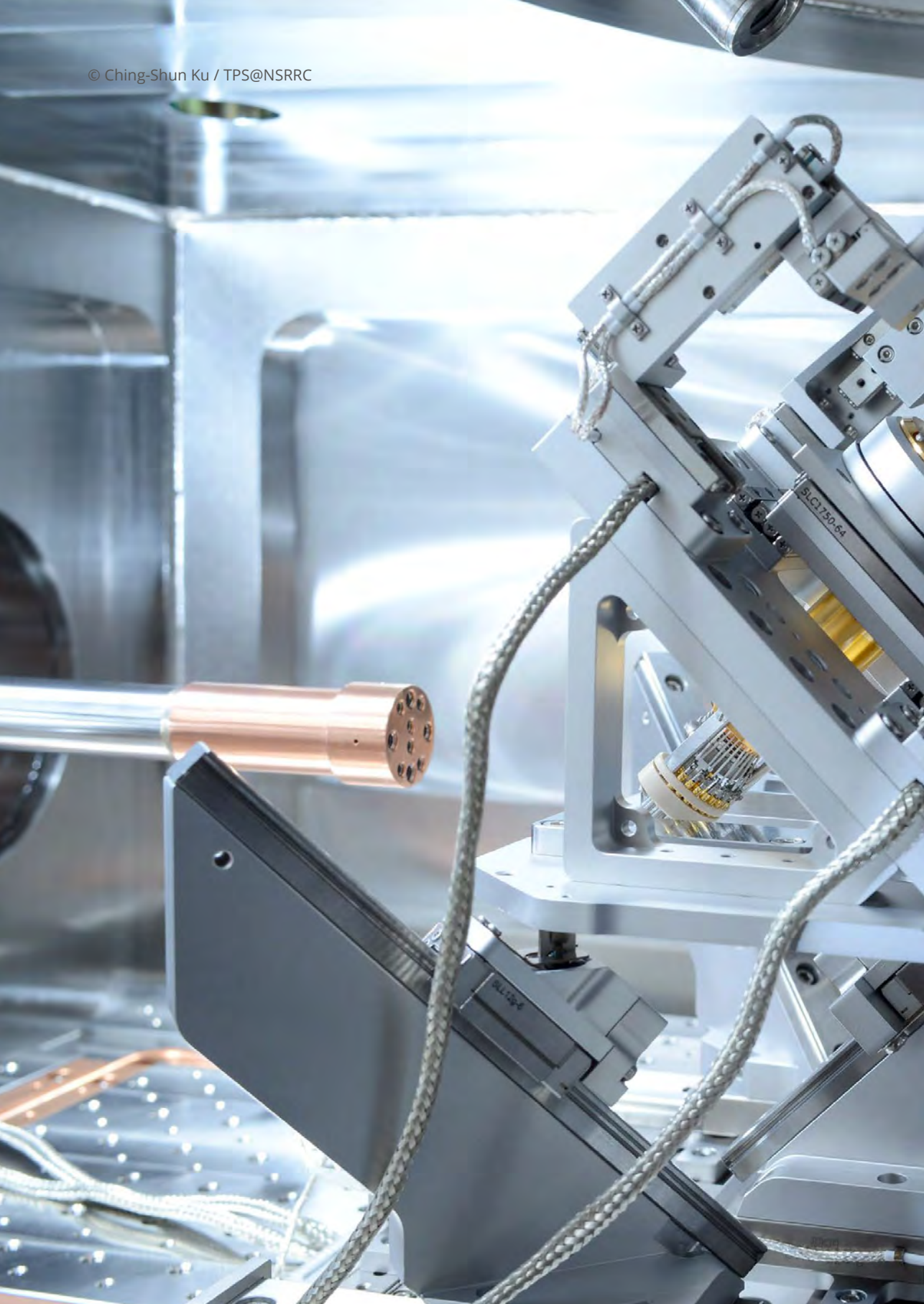
For European Southern Observatory (ESO),
Mt. Cerro Paranal, Chile

The Very Large Telescope array (VLT) is the flagship facility for European ground-based astronomy. It consists of four Unit Telescopes which can be combined to form a giant astronomical interferometer, allowing astronomers to see details much finer than with the individual telescopes.

The light beams are combined using a complex system of mirrors which is designed with only a few moving parts for readjustment. In cooperation with ASTRON Nova, SmarAct developed a compact precision positioner for the use in cryo environments after a previous solution became unavailable.

SmarAct's compact positioning stages were combined with a guiding mechanism to perfectly fit Nova's mirror design and to enable the successful commissioning of the equipment.





Multi-Axis Positioning and Probing System for a Synchrotron Endstation

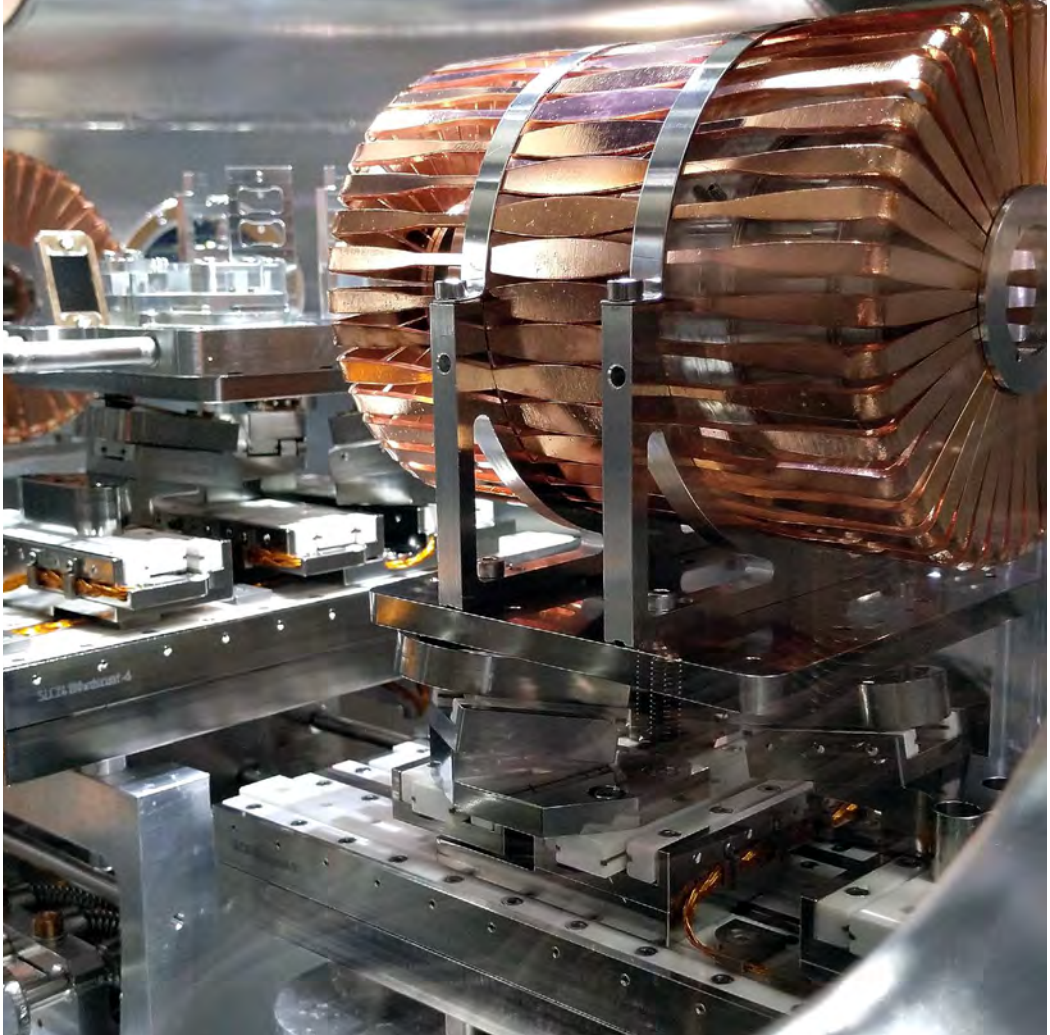
At the FORMOSA Beamline, Taiwan Photon Source (TPS@NSRRC), Hsinchu, Taiwan

Understanding the micro- and nanostructure of materials requires many different analytical techniques. The most sophisticated techniques involve the use of focused x-ray beams generated by a synchrotron light source.

For better understanding of the crystal phases, orientations and strain/stress distribution together with their optical, electrical, mechanical and surface properties, SmarAct developed a unique sample positioning and probing system for the endstation of the "FOcus x-Ray for Micro-Structure Analysis" (FORMOSA) beamline at the Taiwan Light Source.

Combining four micro-manipulators with three degrees of freedom each, a sample stage and a full hexapod-like **SMARPOD** (see page 77) with six degrees of freedom in a compact setup that fits in a tightly confined space of a vacuum chamber.

The multi-axis positioning system allows to move the sample with nanometer resolution in the X-ray beam or orientate it towards the electron column of a SEM which is also connected to the system. The customized **SMARPOD** offers up to 110 mm by 80 mm travel in the horizontal and 70 mm in the vertical plane, allowing for tilt angles of up to 20° in order to align the sample platform to the different detectors mounted to the chamber.

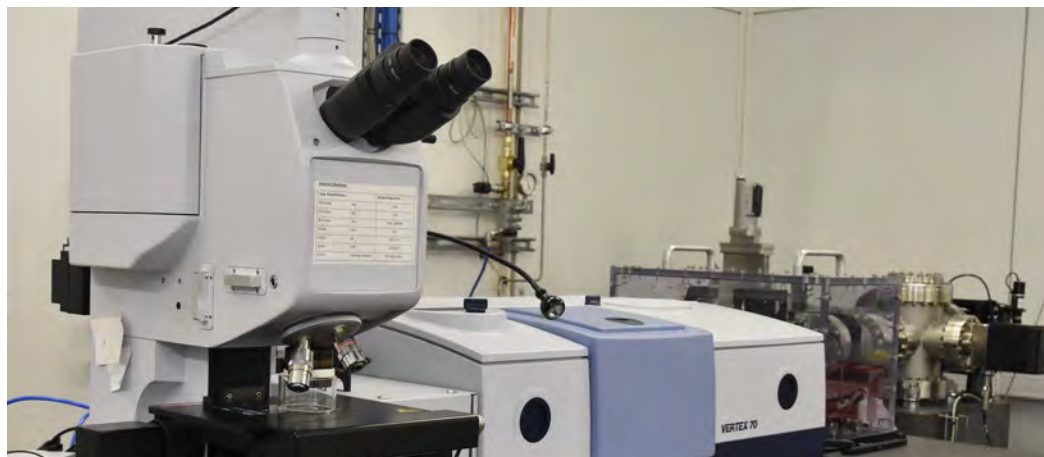


Plasma Acceleration Experiments with SMARPODs

At the REGAE Beamline, DESY, Hamburg, Germany

Laser-plasma accelerators have the potential to become the next-generation technique for the acceleration of electrons. This technique allows these charged particles to be accelerated in a smaller space, thus making the systems more compact. Synchrotron facilities around the world are participating in the progress of this technology. Two non-magnetic SMARPODs (see page 77) are in use in the interaction chamber of the REGAE Beamline at DESY in order to investigate Laser-Plasma Acceleration.

Working at ultra-high vacuum conditions (10^{-9} mbar) and in high-magnetic fields, those SMARPODs have been specially designed in cooperation with the scientists working on this project. Both SMARPODs are capable to carry a load of 1.7 kg and offer a travel range of 149 mm, 49 mm and 2.8 mm in X, Y, and Z, respectively, in order to align a Solenoid and a gas supply stage in six degrees of freedom accurately with a resolution of a single nanometer.



Improved Condenser Alignment in Fourier-Transform Infrared Spectroscopy and Microscopy

At the MIRAS Beamline, ALBA Synchrotron, Barcelona, Spain

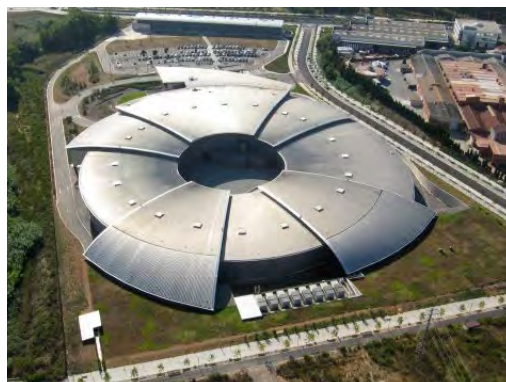


MIRAS works in the field of Fourier-Transform Infrared (FTIR) spectroscopy and microscopy. FTIR is a method to identify the chemical composition of materials by detecting their vibrational signatures. The beamline provides a modern synchrotron-based infrared spectrometer and microscope, covering a wavelength range from approx. 1 to 100 μm with a spectral region optimized for investigation in the range of 2.5 to 14 μm .

The endstation of MIRAS is a Bruker Hyperion 3000 microscope coupled to a Bruker Vertex 70 FTIR spectrometer.

Recently, the condenser holder of the microscope has been replaced by a 4D motorized condenser holder from SmarAct. It provides XYZ motion in a working range of 35 x 18.5 x 24 mm^3 with a resolution < 1 nm and a repeatability < 100 nm per axis, combined with a motorized iris diaphragm (see page 102) with an opening resolution of < 30 nm. The motorized holder has significantly improved the condenser alignment and hence the illumination of the samples by the synchrotron beam.

Many multidisciplinary applications are performed at MIRAS by experts and scientists from different fields of application. SmarAct's motorized condenser holder makes the system more intuitive to operate and more user-friendly.

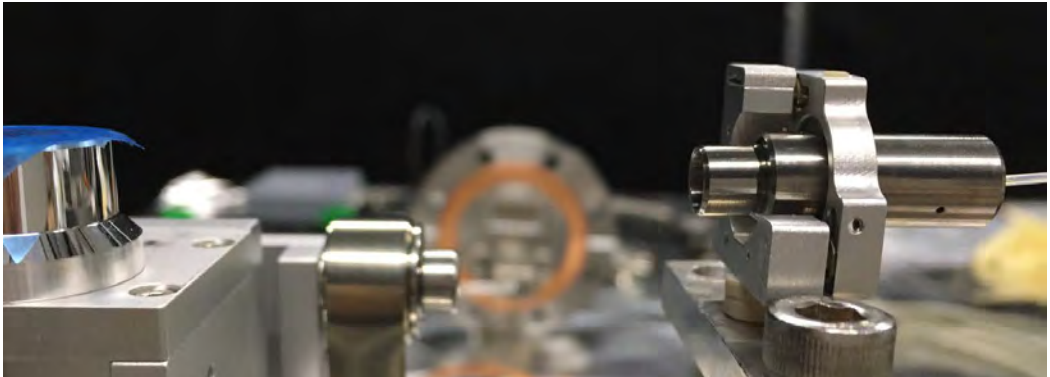


Precise Control of Rotating Objects in Beamlines

For National Synchrotron Radiation Research Center (NSRRC), Hsinchu, Taiwan

A PICOSCALE line focusing sensor head is used to track the motion of a polished cylinder for the use in a synchrotron beamline. Our positioners mounted on a rotation stage allow to place the

cylinder without eccentricity. Alternatively, the cylinder is used with a stub offset to keep the sample stationary.



© Huang-Yeh Chen, NSRRC

7D System for X-Ray Imaging

At the NANOSCOPIUM Beamline,
Synchrotron Soleil, Gif-sur-Yvette, France

The NANOSCOPIUM hard X-ray (5-20 keV) nanoprobe beamline at the Synchrotron SOLEIL is dedicated to multi-technique X-ray imaging using fast scanning and high spatial resolution. The beamline team develops and offers state-of-the-art X-ray nano-imaging and tomography techniques.

The team asked SmarAct to build a 7D sample stage, consisting of CLS modular system components, which was the previous modular system. The positioning system consists of two substages mounted on top each other. The bottom part includes a CLS series linear stage (see page 23 for the improved replacement) with an SHL lifting stage (see page 28) on top and a rotation platform (see page 34). The top substage, which is mounted onto the rotation platform, consists of an XY system made of two CLS linear stages and two goniometer stages (see page 32) as the part on top, forming a Eulerian cradle with a common center of rotation. The XY system allows to precisely position the center of the Eulerian cradle in the axis of the rotation stage, which can be precisely positioned in the beam axis with the help of the linear and lifting stage at the systems bottom.



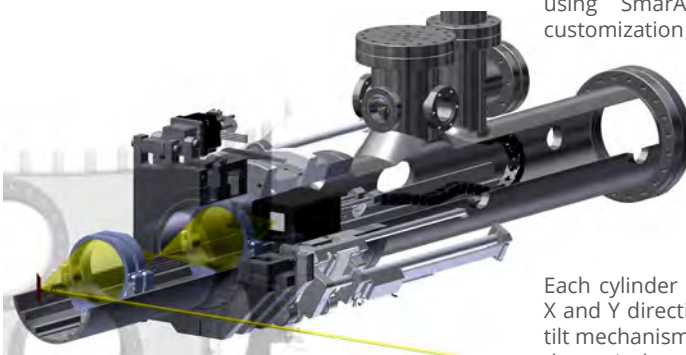


Motion System for Compact von Hamos X-Ray Spectrometer

For National Metrology Institute (PTB),
BESSY II Photon Source, Berlin, Germany

Research on new advanced materials requires improved calibratable X-ray spectrometers aiming for high detection efficiency and high spectral resolution. The National Metrology Institute (PTB) developed a compact von Hamos Spectrometer using SmarAct's positioning technology and customization services.

Up to three full-cylinder optics and a water cooled CCD camera can be adjusted on a 1.2 m long CLL42 linear positioning system with three individually moveable carriages along the optical Z axis.



Each cylinder optics can be individually moved in X and Y direction (± 2 mm) and also includes a tip-tilt mechanism (up to 2°) for a precise alignment of the optical system. The position of the CCD camera is also adjustable in three degrees of freedom. The entire system is ultra-high vacuum compatible and has an outer diameter of less than 150 mm.

© Ina Holfelder, Physikalisch-Technische Bundesanstalt (PTB)

Automated Sample Delivery in Serial Femtosecond Crystallography (SFX)

For Center for Free-Electron Laser Science
(CFEL), University of Hamburg, Germany

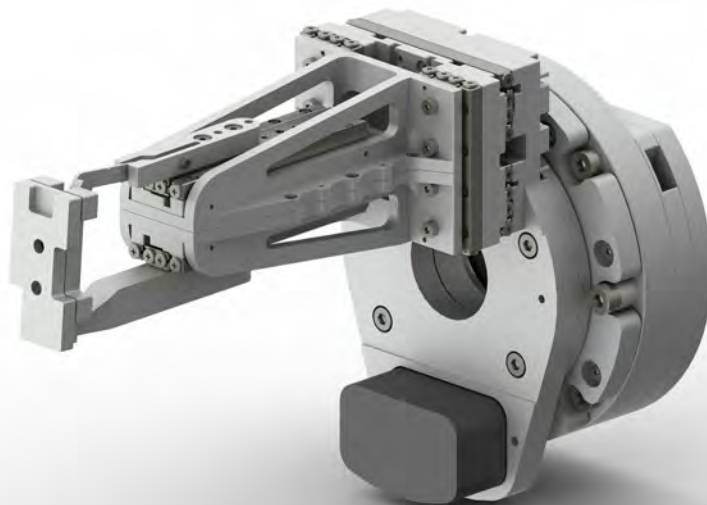
Serial femtosecond crystallography (SFX) uses X-ray pulses from free-electron laser (FEL) sources. SFX may open the way to determine the structure of biological molecules that fail to crystallize readily into large well-diffracting crystals. Taking advantage of FELs with high pulse repetition rates could lead to short measurement times of just minutes. Automated delivery of sample suspensions for SFX experiments could potentially give rise to a much higher rate of obtaining complete measurements than at today's third generation synchrotron radiation facilities, as no crystal alignment or complex robotic motions are required. New challenges arise from the resulting high rate of data collection, and in providing reliable sample delivery.^[1]

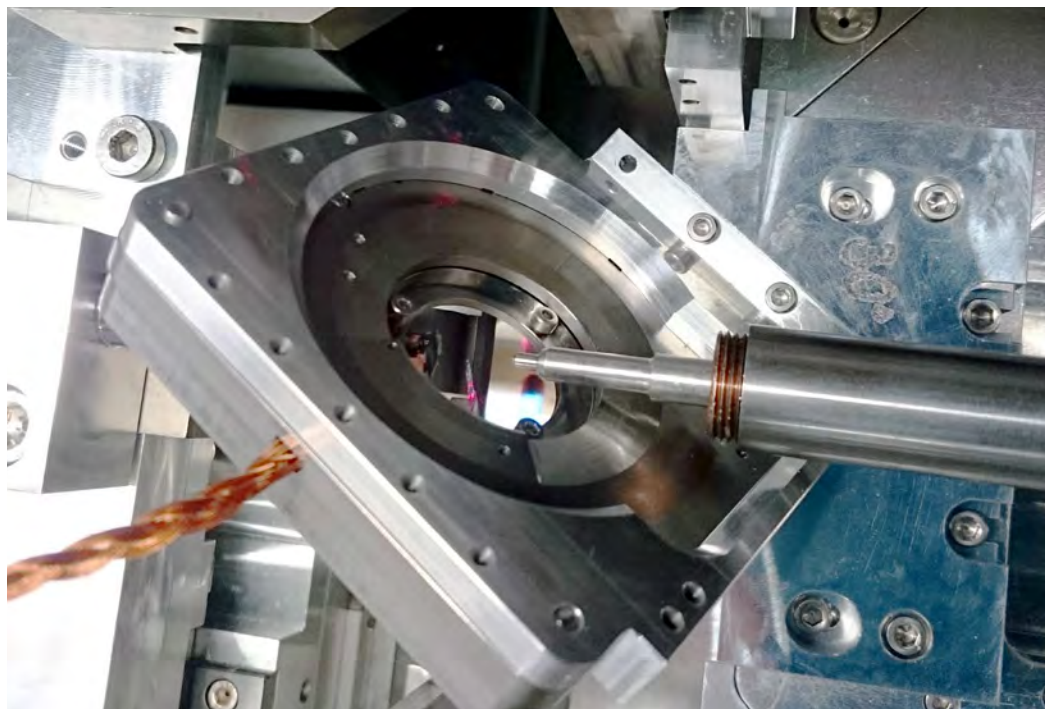
To deliver the samples, an emulsion jet is dispensed in a vacuum chamber via a nozzle that is oriented and positioned by a SmarAct SMARGON

goniometer (see page 32). The goniometer consists of four linear stages that are attached to a larger rotation stage, forming a partially parallel kinematic structure. Each of the stages is equipped with SmarAct's piezo drive technology that provides nanometer-resolved and repeatable movements. The 5D goniometer system allows tilting the liquid jet by $\pm 30^\circ$ and moving it by ± 15 mm. A special feature is a magnetic exchange system that allows picking a nozzle from a nozzle magazine.

SmarAct's 5D goniometer is part of this automated sample delivery system that leads to shorter measurement times and therefore higher sample throughput.

^[1] Possibilities for serial femtosecond crystallography sample delivery at future light sources, L. M. G. Chavas, L. Gumprecht and H. N. Chapman, *Structural Dynamics* 2, 041709 (2015), doi: 10.1063/1.4921220





Customized Rotation Stage for Sophisticated Soft X-Ray Laminography

For Swiss Light Source, Paul Scherrer Institut

3D imaging with synchrotron radiation is a widely used tool that provides impressively detailed insights into the internal structure of complex objects. The short wavelengths of soft X-rays promise spatial resolutions in the low single-digit nanometer range. However, the maximum accessible sample volume is limited by the low penetration depth of soft X-rays.

Laminography, on the other hand, is characterized by the positioning of very thin, laterally extended samples angular to the direction of the X-ray beam. The samples are then rotated around an axis perpendicular to the beam. A camera takes absorption contrast images of the samples in many different positions, which are then used to calculate 3D images of the samples.

The combination of soft X-rays and laminography combines the advantages of both technologies and thus opens up promising perspectives. Potential

applications range from functionalized nanomaterials, biological nanostructures with photonic properties and sophisticated magnetic materials.

For the implementation of soft X-ray laminography (SoXL) at the scanning transmission X-ray spectromicroscope of the PoLux beamline at the Swiss Light Source, Paul Scherrer Institut, a customized high-performance rotation stage with HV compatibility from SmarAct was utilized for the crucial angular sample rotation.

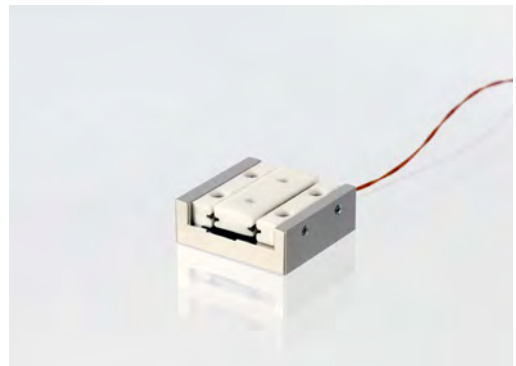
From 2D STXM to 3D Imaging: Soft X-ray Laminography of Thin Specimens, K. Witte, A. Späth, S. Finizio, C. Donnelly, B. Watts, B. Sarafimov, M. Odstrcil, M. Guizar-Sicairos, M. Holler, R. H. Fink, and Jörg Raabe, Nano Letters 2020 20 (2), 1305-1314 DOI: 10.1021/acs.nanolett.9b04782



© Christoph Hohmann (MCQST)

High-precision positioning technology for high-performance quantum networks

A team led by Gerhard Rempe at the Max Planck Institute of Quantum Optics uses SmarAct's nano-precise SMARSLIDE piezo stages to enter the uncharted territory of quantum communications. In order to make this happen, they couple crossed optical fiber cavities to one atom. This setup essentially forms a quantum network node that connects to two quantum channels, one provided by each cavity. It features passive, heralded and high-fidelity quantum memory which isn't dependent on any amplitude- and phase-critical control fields or error-prone feedback loops¹. Furthermore, slight modifications to the crossed optical fiber cavity setup provides non-destructive qubit detection within quantum networks². Both the highly reliable quantum memory system and the nondestructive qubit detection represent breakthroughs that pave the way for fully functional, large-scale quantum networks with multiple connected nodes.



High-precision non-magnetic linear stages like these where utilized in the setup shown in the title picture above.

^[1] A quantum network node with crossed optical fibre cavities, M. Brekenfeld, D. Niemiets, J.D. Christesen, G. Rempe, *Nature Physics* 16, 647-651 (2020), doi: 10.1038/s41567-020-0855-3

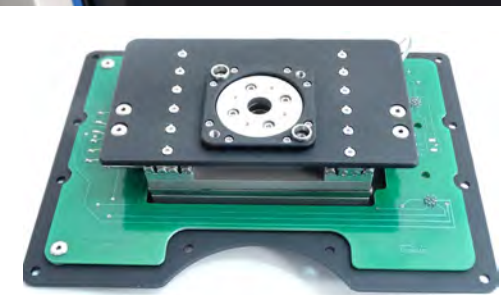
^[2] Nondestructive detection of photonic qubits, D. Niemiets, P. Farrera, S. Langenfeld, G. Rempe, *Nature* 591, 570-574 (2021), doi: 10.1038/s41586-021-03290-z



Highly Compact XYR-Stage for an automated Laser Ablation System

For 3D-MICROMAC AG, Chemnitz, Germany

3D-Micromac's microPREP™ PRO is a laser ablation system complementing existing approaches to sample preparation such as focused ion beam micromachining. It offers up to 10,000 times higher ablation rates and therefore lower cost of ownership compared to focused ion beam methods. microPREP™ PRO is used for fast high-volume sample preparation of metals, semiconductors, ceramics and compound materials for microstruc-



ture diagnostics and failure analysis. The sample preparation stage of the microPREP™ PRO was developed by SmarAct in a cooperation 3D-Micromac AG and ensures for the correct alignment of the material under the laser beam.

The highly compact stage with two translational and one rotational degree of freedom is based on SLC-1780 (see page 14) linear stages and a SR-4011 rotation stage (see page 34). The integrated position encoders guarantee a closed-loop resolution of 100nm of the linear and 500μ° of the rotation axis.

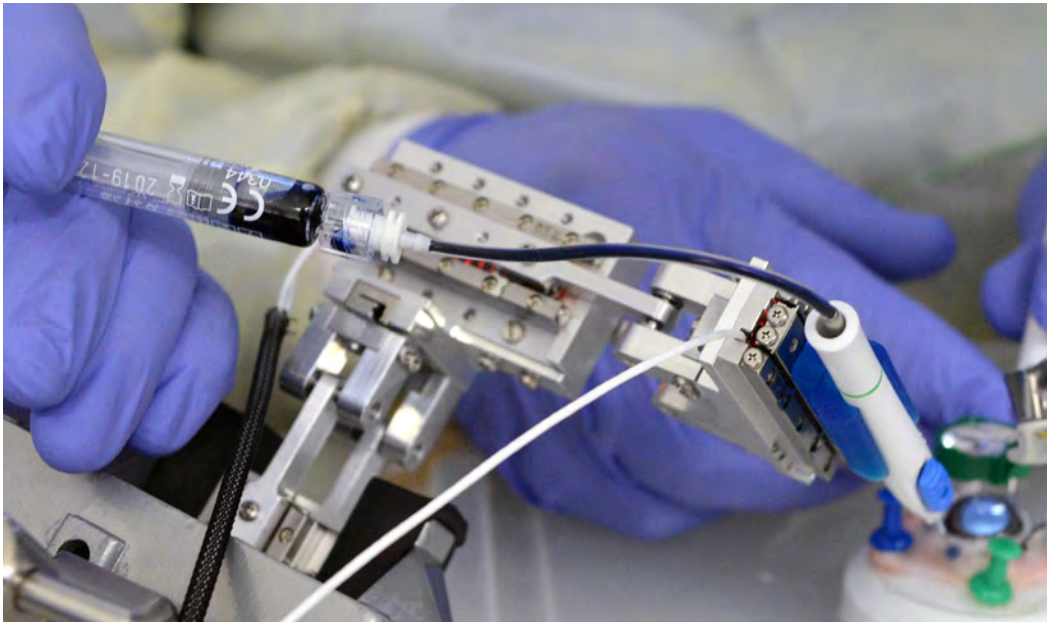
Ophthalmic Drug Delivery Platform

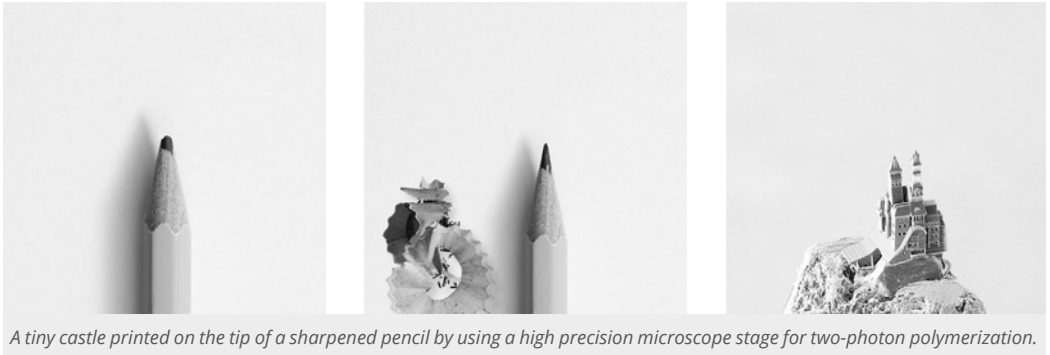
For the Ophthalmology department
of Klinikum rechts der Isar,
Technical University of Munich, Germany

High precision in the treatment of age-related macular degeneration. For a research project of the TU Munich (Augenlinik und Poliklinik, Dr.-Ing. M. Ali Nasser) SmarAct provided a set of piezo-driven SLC-1750 stages (see pages 14) with integrated optical position encoders. With a travel range of 31 mm and an outer dimension of only 17 x 50 8,5 mm the stages represent a perfect compromise between a long travel range and high compactness. These piezo-driven linear stages are the main part of a hybrid parallel-serial kinematic used as a pre-generation medical device that enables ophthalmologists to improve administration of substances such as drugs and stemcells to desired targets located below the retina. The design of the kinematic system allows an end effector precision of 14 μm (x), 10 μm (y) and 4 μm (z). A detailed explanation about the applications of such a drug delivery platform can be found in recent publications of the group ^[1].



^[1] A targeted drug delivery platform for assisting retinal surgeons for treating Age-related Macular Degeneration (AMD), M. A. Nasser et al., 2017 39th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), doi: 10.1109/EMBC.2017.8037815





A tiny castle printed on the tip of a sharpened pencil by using a high precision microscope stage for two-photon polymerization.

High Precision Microscope Stage for Two Photon Polymerization

For UpNano GmbH

Two-photon polymerization (2PP) is not limited to layer-by-layer fabrication, but is an inherent 3D process technology suitable for the fabrication of almost any conceivable 3D structure, including those in the nm range.

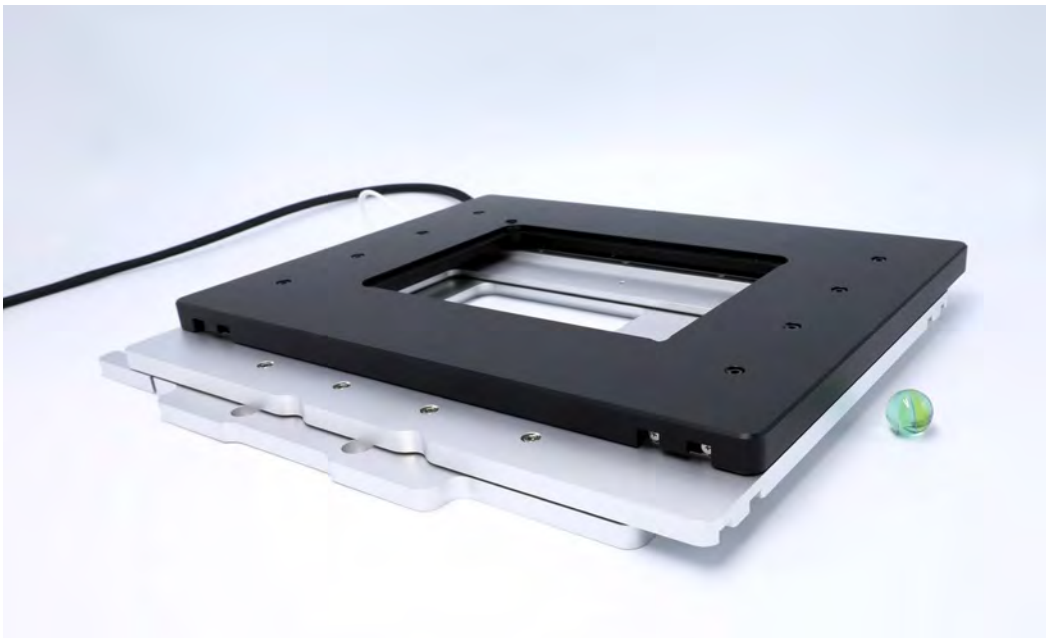
In a transparent, photosensitive liquid material, only the areas that are to polymerize are selectively aligned in a tiny laser focus.

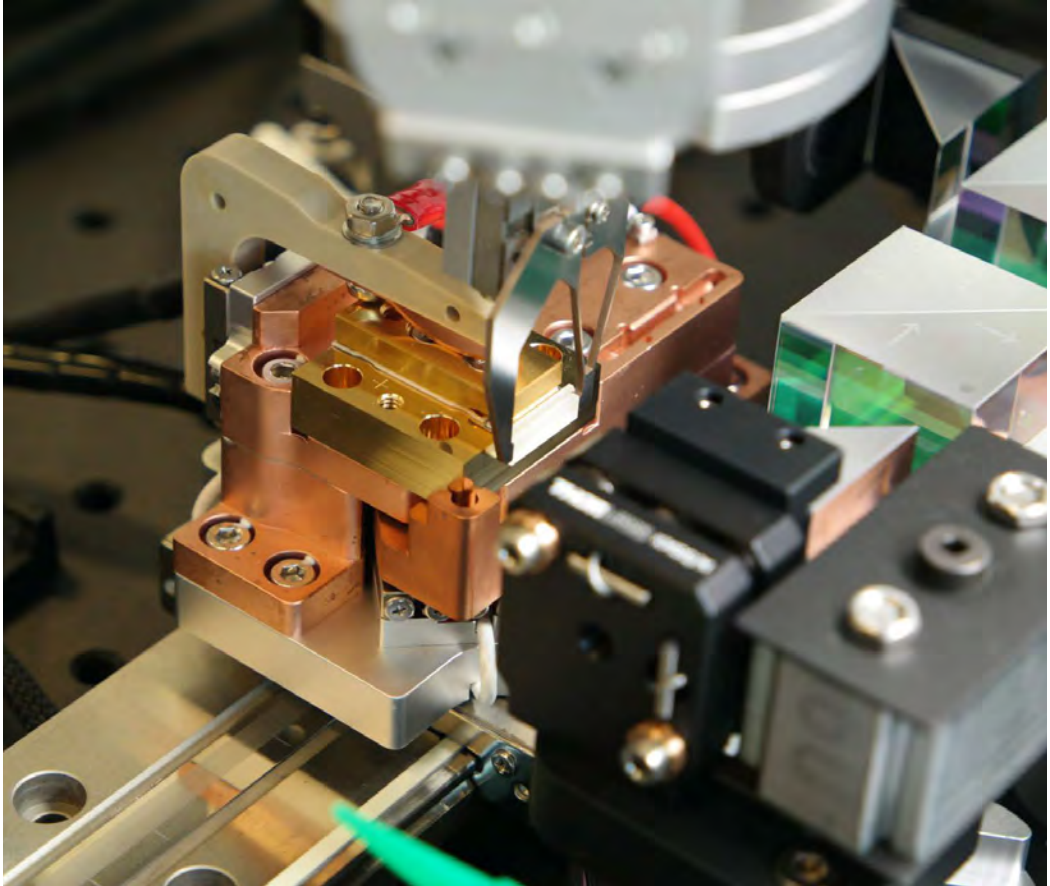
This process is based on the second order absorption of the laser light intensity in the material and therefore requires very high laser focal intensities

at a very small focus as well as the highly precise alignment of the laser focus within the material. The Austrian high-tech company UpNano uses a customized version of SmarAct's SOM-180150 high-precision microscope stage – a long range piezo stage with a travel range of 120 x 100mm – for this purpose.

The stage's motion accuracy combined with the breakthrough 2PP technology offers enormous potential and enables innovative applications in academic and industrial research, e.g. in biomechanics such as tissue engineering.

To demonstrate the capabilities of UpNanos NanoOne, a tiny castle was 3D printed onto the sharpened tip of a pencil using 2PP and then imaged by scanning electron microscopy.





Automated FAC Alignment Station

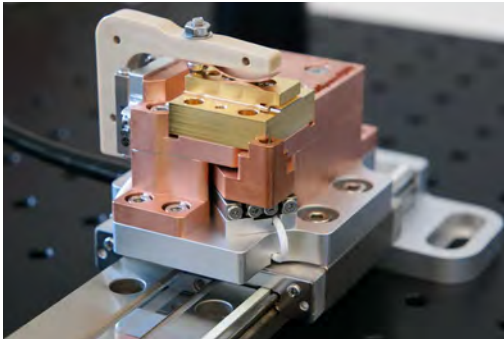
The FAC Alignment Station automates the assembly of Fast Axis Collimation (FAC) lenses to laser diodes. The complete process, starting with contacting laser modules up to the final measurements of beam

collimation after adhesive curing. In less than 25 seconds, the alignment of the lens in front of a multi-emitter laser diode bar is achieved.

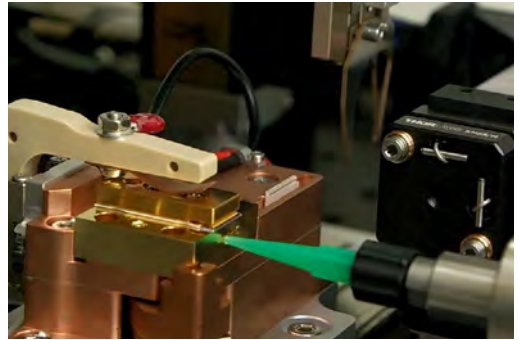
FAC Station Features

<p>Laser diode bars Visible and near infrared wavelengths Operation at up to 50 W pulsed</p>	<p>Alignment resolution using SMARPOD Down to 1 nm translational steps Down to 1 μrad rotational steps</p>
<p>Active alignment Single and multiple emitters Alignment in less than 25 seconds</p>	<p>Grippers Customized gripper jaws for deterministic gripping Gripper jaws for objects from 50 μm to several cm Force-feedback gripping for delicate objects</p>
<p>Alignment station features Automatic laser module clamping and referencing Needle valve, volumetric or jet dispensers Integrated UV-curing source</p>	<p>Control software User interface for monitoring and manual control Scripting interface for process development Customized GUI for small series production</p>

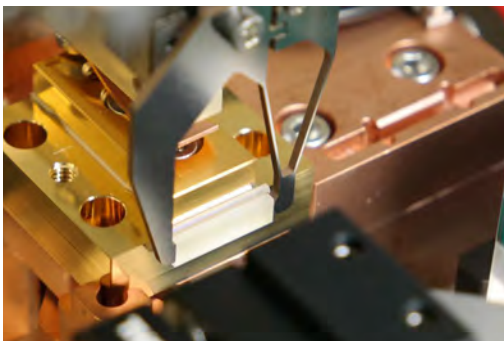
Process Steps



Loading:
Upon loading, the laser modules are centered and connected automatically. The laser mount serves as heat sink.



Dispensing:
Adhesive is dispensed in just the right amount. Here we employ a needle valve dispenser.

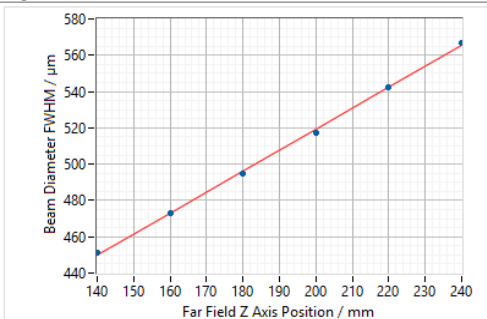


Gripping:
A SmarAct micro gripper is used to manipulate the lens.

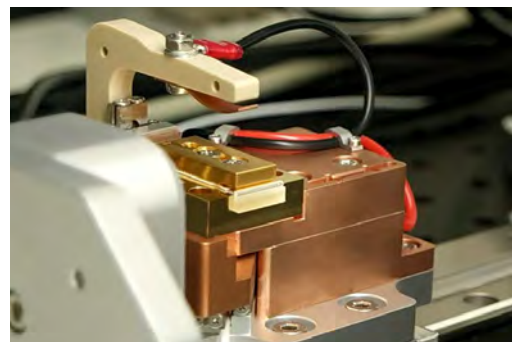


Active alignment:
Sensor feedback from the beam analysis optics is used to precisely align the lens in front of the laser using a SMARPOD.

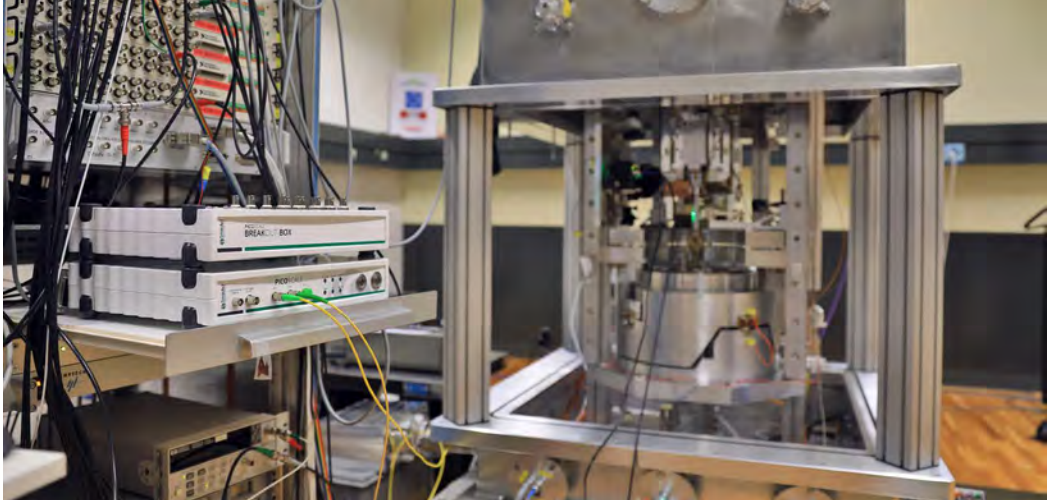
Divergence Measurement



Post-cure measurement:
After curing the final optical characteristics are measured.



Unloading:
The assembled module is released to be unloaded.



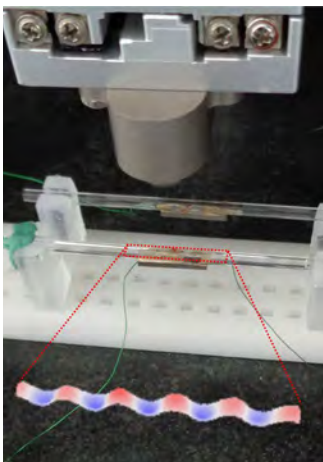
The Watt Balance: An Experiment to Realize the New Definition of the Kilogram

For METAS, Federal Institute of Metrology,
Berne, Switzerland

The Watt balance is comparing mechanical and electrical powers. In a first step, the mechanical force on a test mass in the earth's gravitational field is balanced with an electromagnetic force using a current-carrying coil. In a second step, the coil is moved through the magnetic field, which induces a voltage. The precise knowledge of the electrical, gravitational and dynamical properties allows

to infer the mass by using natural constants only, which allows to redefine the kilogram - instead of using the prototype mass in Paris. One requirement during the two phases of the experiment is the accurate determination of the position and angular orientation of the coil. This measurement is performed using the *PICOSCALE Interferometer*.

*For details please refer to
<https://www.metas.ch/metas/en/home/fue/forschungsprojekte/wattwaage.html>*



Modal Analysis of Acoustofluidic Devices

For ETH Zurich, Switzerland

Particle manipulation in microfluidics with acoustic fields is a promising technique with applications that range from 3D metal printing to life science. The research group of Professor Jürg Dual at the Institute of Mechanical Systems at the ETH in Zurich operates at the forefront of the fundamental research on such acoustofluidic devices. Of key interest is the understanding of how induced mechanical vibrations of the device can lead to well-defined pressure fields in the liquid.

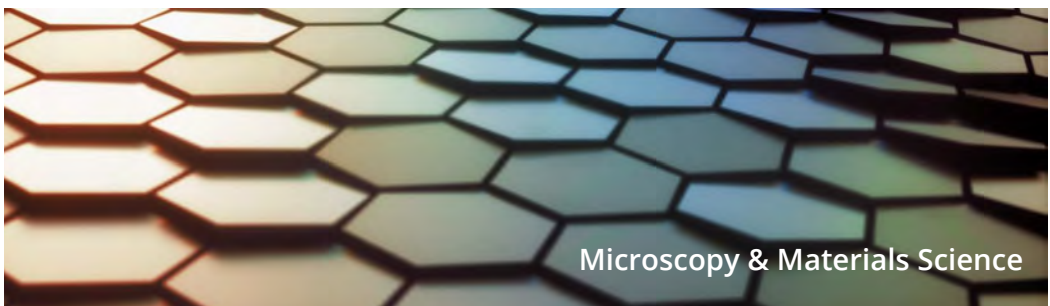
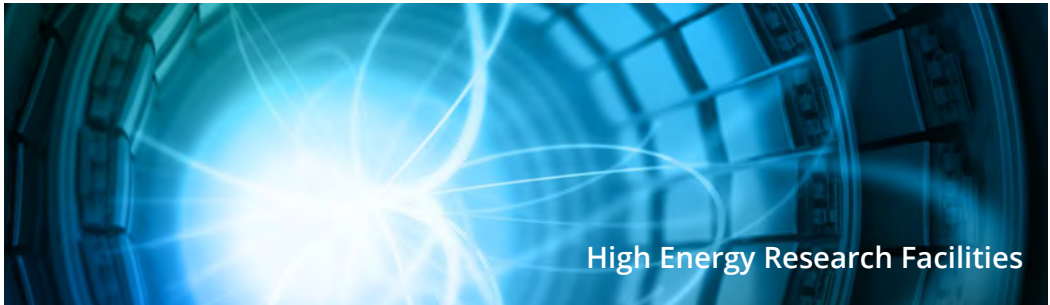
The confocal optical design of the *PICOSCALE Vibrometer* makes it possible to image the nanometer vibrations of the multi-layered transparent devices which helps to understand and to improve their performance.

Markets and Applications

SmarAct Products Applied

SmarAct is your reliable partner for high tech made in Germany in the fields of high precision positioning, micro automation and metrology.

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You are always welcome to contact us.

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Since its founding in 2005, SmarAct has steadily grown from a small team of engineers to a group of companies with three independent business units and over 220 highly skilled members. Today, SmarAct relies on years of experience and, above all, on a very passionate team with unconditional customer focus.

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