attocube
WITTENSTEIN group

Motion & Sensing

piezo-based nanopositioners

ambient & vacuum

MOTION & SENSING
precision engineering components

Technology Leader in Nanopositioning

attocube is the technology leader in piezo-based nanopositioning.The company stands out with patented technologies and years of experience in nanopositioning for extreme environments such as ultra-high vacuum, cryogenic to elevated operating temperatures, and high magnetic fields. The nanopositioner division focuses on the design, engineering and manufacturing of piezoelectric motor-driven stages and integrated nanopositioning solutions for applications with the highest requirements on resolution, precision and stability.

The portfolio covers linear, rotary, and goniometric positioners and scanners and combines motion over centimeter ranges with proven nanometer precision. Customized engineering solutions complete the portfolio. All components are developed, manufactured, and tested at the company's headquarters in Germany. Years of experience and a highly skilled team guarantee highest levels of consulting competence and excellent after-sales support.

Nanopositioners
for ambient & vacuum conditions

Ambient & Vacuum Nanopositioners

attocube ambient and vacuum nanopositioners all incorporate a piezoelectric motor to achieve motion with nanometer precision and are available in a variety of different materials depending on the customer's application. Nanopositioners for use in ambient conditions are made of light-weight and strong aluminium, while a stainless steel housing is compatible with vacuum conditions up to 5 x 10^{-11} mbar and titanium is employed for non-magnetic requirements.

Different sizes and types of positioners are available for versatile needs. The bearing-based ECS series is a more rugged and cost efficient option, while the ANP series is suitable for special requirements such as limited space or non-magnetic demands. Use the product finder on the following pages to identify the most suitable model for your requirements.

1 Extreme Environments

- down to 5 x 10^{-11} mbar — UHV pressure
- Clean Room — up to ISO Class 5 — low particle generation
- up to 150 °C — bakeable
- up to 35 T — magnetic fields

2 Precise & Powerful

- down to 1 nm — resolution
- up to 20 N — maximum load

3 Flexible Positioning

- linear positioners — vertical/horizontal
- goniometers — Θ & Φ positioning
- rotators — up to 360°
- stacks — mult-axis positioning

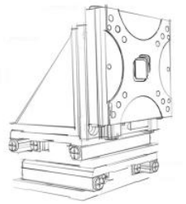
ambient. & vacuum

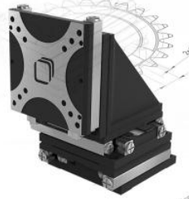
Customized Nanopositioning Solutions

nanopositioning tailored to your application

Many high precision applications have specific requirements concerning e.g. certification, travel range, or clean room compatibility. For these applications, attocube offers a broad range of customized components and sub-modules as well as integrated systems solutions, exactly tailored to the customers specific needs.

Combining attocubes competencies in nanopositioning and interferometry with years of experience in challenging and extreme environments guarantees highest levels of consulting competence and products that work with highest realiability, pushing the limits of technical feasibility.

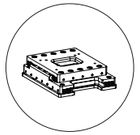




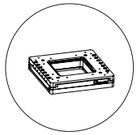
Design OEM Manufacture

Expertise from design to manufacturing

Customized Solutions Examples

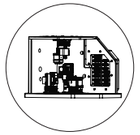


Spectroscopy Stage



Microscopy Stage

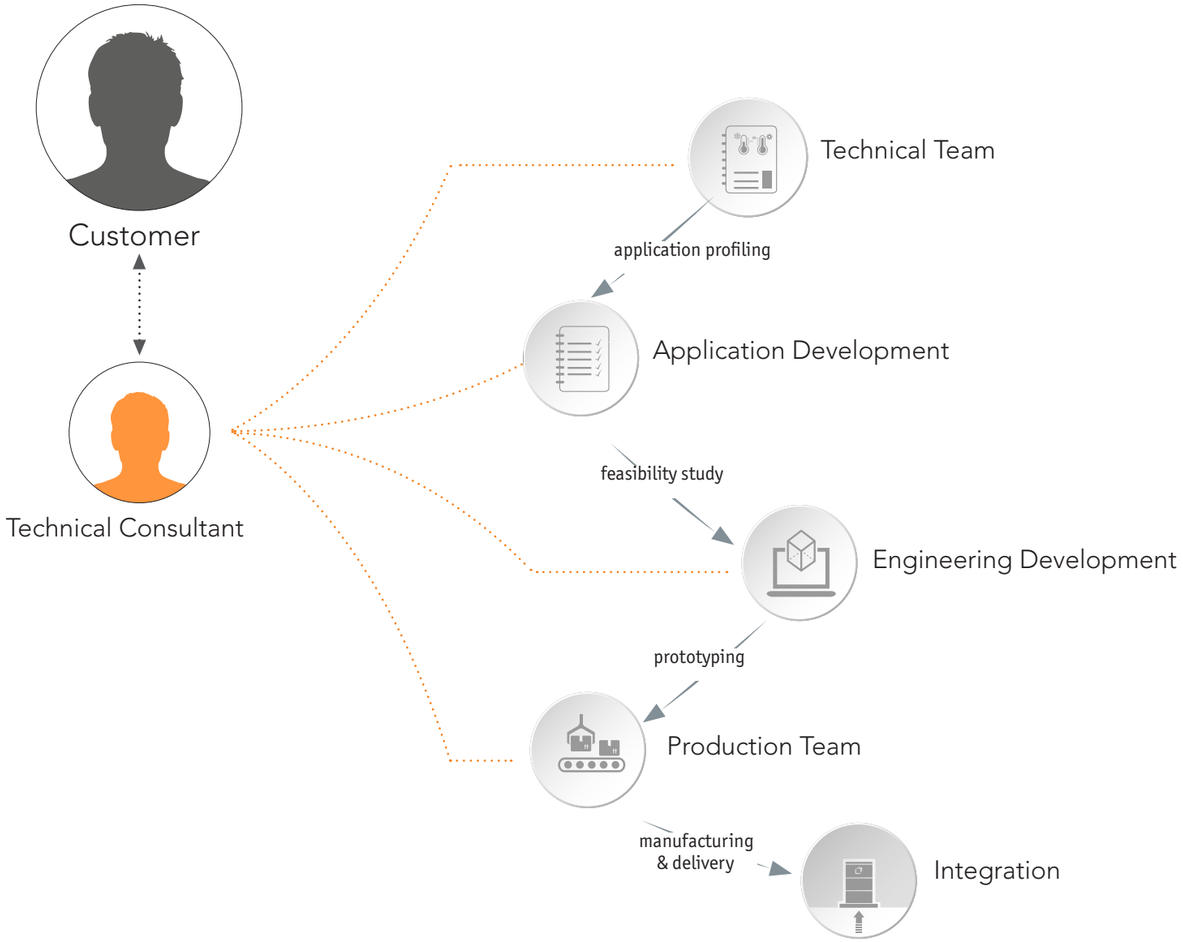
Multiaxis Solution



Imaging System

How do customizations work at attocube?

where ideas become results



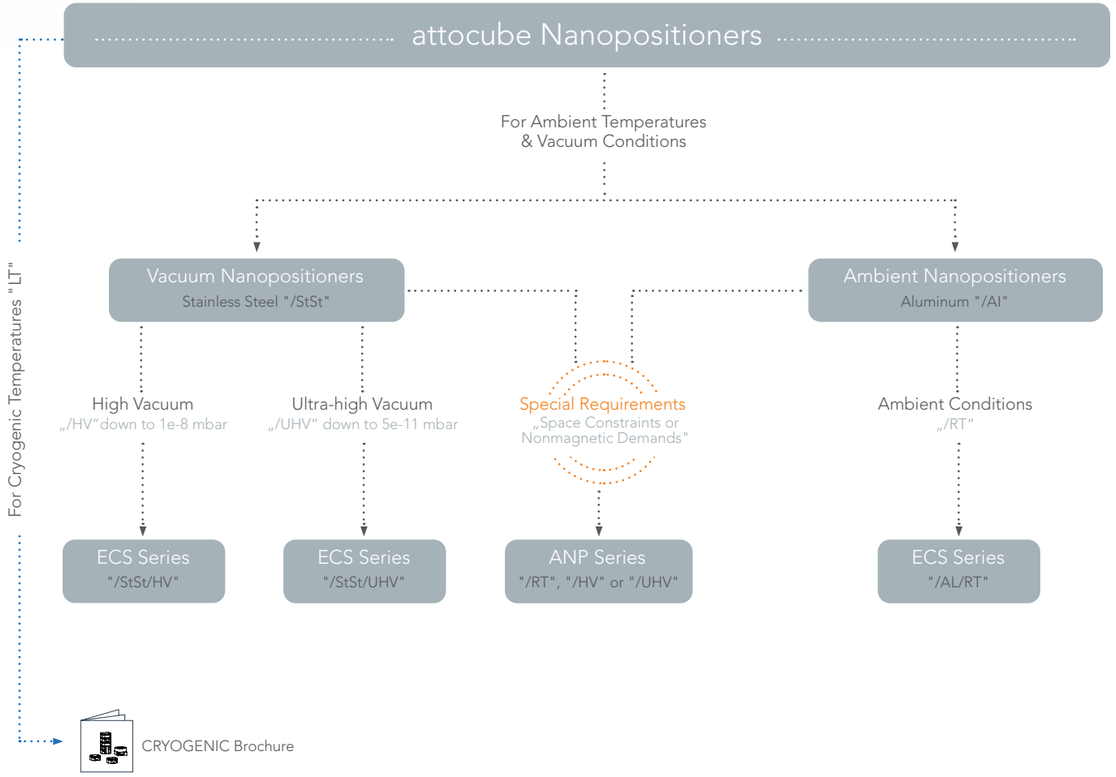
Product Finder

which positioner fits your application?

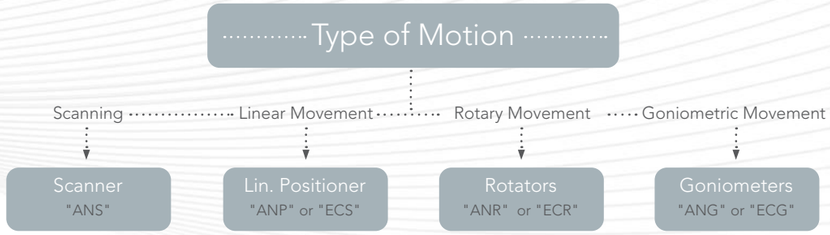
The product finder helps you to identify the most suitable model for your requirements. It indicates the respective positioner series (ECS or ANP) and the suffix in the naming scheme of attocube nanopositioners (e.g. "/StSt" for stainless steel, "/Al" for aluminium etc.).

In step 1 you can opt for the respective working environment, while step 2 leads you to the desired direction of movement and step 3 indicates whether internal position control is required or not.

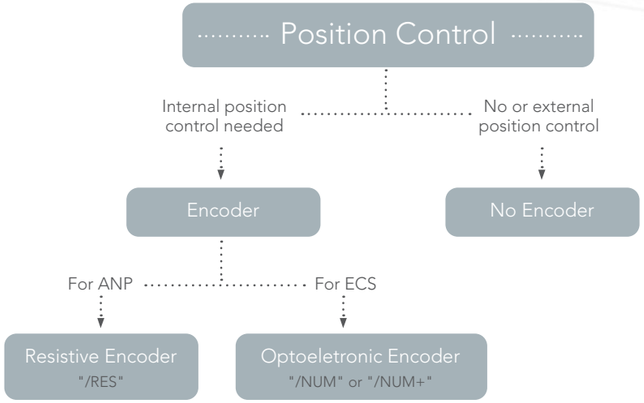
Step 1



Step 2



Step 3



Linear Positioners



Linear Positioners	ECSx5050	ECSxy5050	ECSz5050
Options			
environment	/RT, /HV, /UHV	/RT	/RT
encoder	/NUM, /NUM+	/NUM	/NUM
high load	/HL(*)	---	---
Dimensions			
footprint; height	50 x 50; 9.5 mm	50 x 50; 16.4 mm	50 x 50; 32 mm
Positioning Mode @ Ambient Conditions			
travel range	30 mm	25 x 25 mm²	8 mm
drive velocity	4.5 mm/s	4.5 mm/s	2 mm/s
maximum load	20 N	20 N	8 N
dynamic drive force	1 N (high load *5 N)	2 N	8 N
Closed Loop Features			
resolution /NUM	1 nm	1 nm	1 nm
repeatability /NUM	50 nm	50 nm	100 nm




Linear Positioners	ECSx3080	ECSx3050	ECSx3030	ECSz3030
Options				
environment	/RT, /HV, /UHV	/RT, /HV, /UHV	/RT, /HV, /UHV	/RT
encoder	/NUM, /NUM+	/NUM, /NUM+	/NUM, /NUM+	/NUM
high load	/HL(*)	/HL(*)	---	---
Dimensions				
footprint; height	30 x 80; 9.5 mm	30 x 50; 9.5 mm	30 x 30; 9.5 mm	31 x 30; 31.5 mm
Positioning Mode @ Ambient Conditions				
travel range	50 mm	30 mm	20 mm	5 mm
drive velocity	4.5 mm/s	4.5 mm/s	4.5 mm/s	2 mm/s
maximum load	20 N	20 N	10 N	8 N
dynamic drive force	1 N (high load *5 N)	1 N (high load *5 N)	1 N	8 N
Closed Loop Features				
presolution /NUM	1 nm	1 nm	1 nm	1 nm
repeatability /NUM	50 nm	50 nm	50 nm	50 nm

Naming Scheme

Type of Positioner	Direction of Movement	Dimension	Options	Environment	Encoder
ECS linear nanopositioner	x enabling movement in x or y direction	50xx positioner width in mm	/HL high load version	/RT room temperature	/NUM (+) closed loop control based on an optoelectronic encoder
	xy enabling movement in x and y direction	xx50 positioner length in mm		/HV high vacuum	
	z enabling movement in z direction			/UHV ultra-high vacuum	

Linear Positioners




Linear Positioners	ANPx341	ANPx321	ANPx311	ANPz102
Options				
environment	/RT, /HV, /UHV	/RT, /HV, /UHV	/RT, /HV, /UHV	/RT, /HV, /UHV
encoder	/RES	/RES	/RES	/RES
high load	/HL(*)	/HL(*)	/HL(*)	---
Dimensions				
footprint; height	40 x 45; 11.5 mm	40 x 41.6; 11.5 mm	30 x 30; 10 mm	24 x 24; 27 mm
Positioning Mode @ Ambient Conditions				
travel range	20 mm	15 mm	6 mm	4.8 mm
drive velocity	3 mm/s	3 mm/s	3 mm/s	3 mm/s
maximum load	20 N	20 N	20 N	2 N
dynamic drive force	2 N (*20N vertical mounting)	2 N (*20N vertical mounting)	2 N	5 N
Closed Loop Features				
resolution /RES	200 nm	200 nm	200 nm	200 nm
repeatability /RES	1-2 µm	1-2 µm	1-2 µm	1-2 µm





Linear Positioners	ANPz101	ANPx101	ANPz51	ANPx51	ANPz30
Options					
environment	/RT, /HV, /UHV	/RT, /HV, /UHV	/RT, /HV, /UHV	/RT, /HV, /UHV	/RT, /HV, /UHV
encoder	/RES	/RES	/RES	/RES	---
high load	/HL(*)	---	---	---	---
Dimensions					
footprint; height	24 x 24; 20 mm	24 x 24; 11 mm	15 x 15; 13.5 mm	15 x 15; 9.2 mm	ø 11; 12 mm
Positioning Mode @ Ambient Conditions					
travel range	5 mm	5 mm	2.5 mm	3 mm	2.5 mm
drive velocity	3 mm/s	3 mm/s	1 mm/s	1 mm/s	1 mm/s
maximum load	2 N	1 N	0.5 N	0.25 N	0.1 N
dynamic drive force	5 N (high load *3 N)	2 N	1 N	1 N	0.2 N
Closed Loop Features					
resolution /RES	200 nm	200 nm	200 nm	200 nm	----
repeatability /RES	1-2 µm	1-2 µm	1-2 µm	1-2 µm	---

Naming Scheme

Type of Positioner

ANP linear nanopositioner

Direction of Movement

x enabling movement in x or y direction
z enabling movement in z direction

Dimension

3x positioner series with smallest available footprint
5x positioners designed for a 1" clear bore size
10x positioners designed for a 2" clear bore size
3xx linear positioners with integrated bearings

Options

/HL high load version

Environment

/RT room temperature
/HV high vacuum
/UHV ultra-high vacuum

Encoder

/RES closed loop control based on a resistive encoder

Scanners




Scanners	ANSx150	ANSxyz100/std	ANSxy100/std	ANSxy100/lr
Options				
environment	/RT, /HV, /UHV	/RT, /HV, /UHV	/RT, /HV, /UHV	/RT, /HV, /UHV
Dimensions				
footprint; height	24 x 24; 9 mm	24 x 24; 10 mm	24 x 24; 10 mm	24 x 24; 10 mm
Scan Mode				
fine positioning range @ 300 K	80 µm	50 x 50 x 24 µm³	40 x 40 µm²	50 x 50 µm²
fine positioning range @ 4 K	125 µm	30 x 30 x 15 µm³	9 x 9 µm²	30 x 30 µm²
maximum load	1 N	1 N	1 N	1 N





Scanners	ANSz100/std	ANSz100/lr	ANSxyz50	ANSxy50	ANSz50
Options					
environment	/RT, /HV, /UHV	/RT, /HV, /UHV	/RT, /HV, /UHV	/RT, /HV, /UHV	/RT, /HV, /UHV
Dimensions					
footprint; height	24 x 24; 10 mm	24 x 24; 12 mm	15 x 15; 13 mm	15 x 15; 7 mm	15 x 15; 6 mm
Scan Mode					
fine positioning range @ 300 K	24 µm	50 µm	30 x 30 x 4.3 µm³	30 x 30 µm²	4.3 µm
fine positioning range @ 4 K	15 µm	30 µm	15 x 15 x 2 µm³	15 x 15 µm²	2 µm
maximum load	1 N	1 N	0.5 N	0.5 N	0.5 N

Naming Scheme

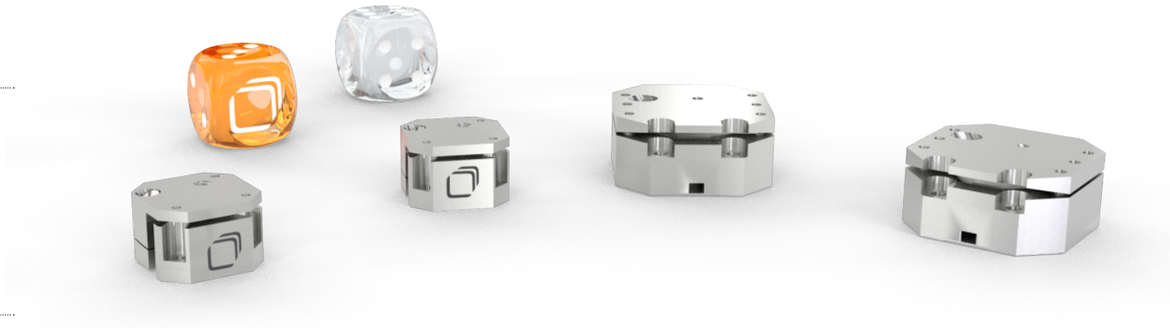
Type of Positioner	Direction of Movement	Dimension	Options	Environment
ANS scanner	x enabling movement in x or y direction	5x positioners designed for a 1" clear bore size	/std standard range option	/RT room temperature
	xy enabling movement in x and y direction	10x positioners designed for a 2" clear bore size	/lr large range option	/HV high vacuum
	z enabling movement in z direction	150 scanner with extended scan range at cryogenic temperatures		/UHV ultra-high vacuum
	xyz enabling movement in x, y and z direction			

Goniometers






Goniometers	ECGt5050	ECGp5050	ANGt101	ANGp101	ANGt50	ANGp50
Options						
environment	/RT, /HV, /UHV	/RT, /HV, /UHV	/RT, /HV, /UHV	/RT, /HV, /UHV	/RT, /HV, /UHV	/RT, /HV, /UHV
encoder	/NUM, /NUM+	/NUM, /NUM+	/RES	/RES	---	---
high load	/HL(*)	/HL(*)	---	---	---	---
Dimensions						
footprint; height	50 x 50; 17 mm	50 x 50; 17 mm	24 x 24; 11 mm	24 x 24; 11 mm	15 x 15; 10 mm	15 x 15; 10 mm
Positioning Mode @ Ambient Conditions						
travel range	10°	10°	6.6°	5.4°	7.2°	5.8°
drive velocity	approx. 3°/s	approx. 3°/s	1°/s	1°/s	1°/s	1°/s
maximum load	10 N	10 N	1 N	1 N	0.25 N	0.25 N
dynamic torque around axis	7 Ncm (high load *35 Ncm)	8,7 Ncm (high load *43,5 Ncm)	10 Ncm	10 Ncm	3 Ncm	3 Ncm
Closed Loop Features						
resolution	1 µ° (NUM)	1 µ° (NUM)	0,1 m° (RES)	0,1 m° (RES)	---	---
repeatability	50 µ° (NUM)	50 µ° (NUM)	2 m° (RES)	2 m° (RES)	---	---



Naming Scheme

Type of Positioner

- ECG goniometer
- ANG goniometer

Direction of Movement

- p enabling angular movement in „phi“
- t enabling angular movement in „theta“

Dimension

- 50xx positioner width in mm
- xx50 positioner length in mm
- 5x positioners designed for a 1” clear bore size
- 10x positioners designed for a 2” clear bore size

Options

- /HL high load version

Environment

- /RT room temperature
- /HV high vacuum
- /UHV ultra-high vacuum

Encoder

- /NUM closed loop control based on an optoelectronic encoder
- /RES closed loop control based on a resistive encoder

Rotators





Rotators	ECR5050hs	ECR4040	ECR3030	ANR240	ANRv220
Options					
environment	/RT, /HV, /UHV	/RT	/RT, /HV, /UHV	/RT, /HV, /UHV	/RT, /HV, /UHV
encoder	/NUM, /NUM+	/NUM	/NUM	/RES	/RES
high load	---		---		---
Dimensions					
footprint; height	50 x 50; 15 mm	40 x 40; 14.5 mm	30 x 30; 13.5 mm	35 x 35; 13.5 mm	27 x 12; 27 mm
Positioning Mode @ Ambient Conditions					
travel range	360°	360°	360°	360°	360°
drive velocity	approx. 10°/s	approx. 10°/s	approx. 10°/s	30°/s	30°/s
maximum load	20 N	20 N	5 N	2 N	1 N
dynamic torque around axis	1 Ncm	1 Ncm	0,5 Ncm	2 Ncm	1 Ncm
Closed Loop Features					
resolution	0.01 m° (NUM)	0.04 m° (NUM)	0.01 m° (NUM)	6 m° (RES)	6 m° (RES)
repeatability	1 m° (NUM)	4 m° (NUM)	1 m° (NUM)	50 m° (RES)	50 m° (RES)




Rotators	ANR101	ANRv51	ANR51	ANR31
Options				
environment	/RT, /HV, /UHV	/RT, /HV, /UHV	/RT, /HV, /UHV	/RT, /HV, /UHV
encoder	/RES	/RES	/RES	---
high load	---		---	
Dimensions				
footprint; height	24 x 24; 15.2 mm	10 x 20; 21 mm	15 x 15; 9.5 mm	ø 10; 7.5 mm
Positioning Mode @ Ambient Conditions				
travel range	360 °	360 °	360 °	360 °
drive velocity	30 °/s	10 °/s	10 °/s	3 °/s
maximum load	1 N	0.2 N	0.3 N	0.05 N
dynamic drive torque	0.8 Ncm	0.2 Ncm	0.2 Ncm	0.03 Ncm
Closed Loop Features				
resolution	6 m° (RES)	6 m° (RES)	6 m° (RES)	---
repeatability	50 m° (RES)	50 m° (RES)	50 m° (RES)	---

Naming Scheme

Type of Positioner
- ECR rotator
- ANR rotator

Direction of Movement
- v horizontal rotation axis

Dimension
- 50xx positioner width in mm
- xx50 positioner length in mm
- 3x positioner series with smallest available footprint
- 5x positioners designed for a 1" clear bore size
- 10x positioners designed for a 2" clear bore size
- 2x0 rotator with ultra-low wobble

Options
- hs high stability option

Environment
- /RT room temperature
- /HV high vacuum
- /UHV ultra-high vacuum

Encoder
- /NUM closed loop control based on an optoelectronic encoder
- /RES closed loop control based on a resistive encoder

Controller Overview

piezo positioning electronics and accessories

Highest-precision piezo positioning systems require state-of-the-art control electronics. attocube's FPGA-based motion controllers are adapted to the technical challenges of positioners and scanners dedicated for cutting-edge applications and experiments. The AMC100 table-top controller is the model of choice for applications with ECS series positioners, while the ANP series nanopositioners can be accompanied by 19" rack electronics for laboratory environments. Suitable accessories for attocube's positioners are listed below.

For all ANS scanners

ANC250

- ultra low noise scan voltage amplifier (20 µV rms)
- three channels with up to 200 V (differential)

For all ECS positioners

AMC100

- OEM board available (IMC)
- Ethernet or USB (with adapter) connectable
- optional I/O upgrade
- optional PRO upgrade

For all open loop ANP positioners & ANS scanners

ANC300

- modular design
- slots for up to 7 plug-in modules
- combined stepping & scanning possible
- controlling via frontpanel or PC

For all closed loop ANP positioners

AMC300

- position readout
- controlling via display, PC or remote control
- tabletop or 19" rack versions
- pre-implemented libraries as API wrappers

Accessories

Adapter Plates AAP & EAP

- for vertical mounting of ANP positioners
- for cross-mounting of differently sized ANP & ECS positioners

ECS Lift 3030/5050

- suitable for ECSx3030 and ECSx5050
- for lifting high loads exceeding the capabilities of the ECSz3030 or ECSz5050
- ultra-high vacuum compatible

Vacuum Feedthrough Solution

- for connecting positioners mounted in a vacuum chamber to the motion controller
- different sizes are available
- suitable cabling is available

Toolbox

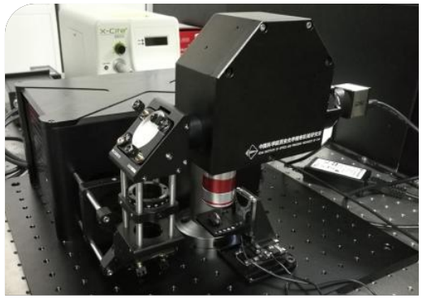
- including titanium screws, pin plugs, wires, base plates, screwdrivers and a tweezer
- available as nanopositioning toolbox or as RES toolbox (integration of an ANP/RES)

Applications

pushing precision in motion

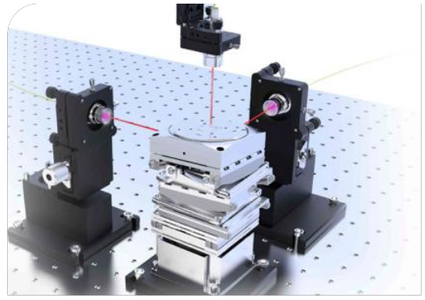
High precision applications in science and technology require nanotechnology solutions that deliver highest resolution and stability. Additionally, they are often conducted under extreme conditions such as ultra-high vacuum, high magnetic fields or radiation harsh environments.

attocube positioners are designed for a broad range of applications where highest precision, reliability, space constraints, or challenging environmental conditions are key. In this section you will find a snapshot of the main application fields and some dedicated application examples. Contact us to discuss your special requirements and setup.



Microscopy Application

precise motion for microscopes

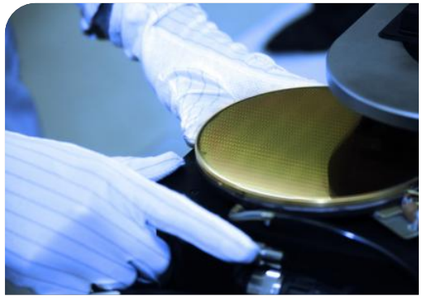


Nanoprecise Positioning

multiple axis positioning stages

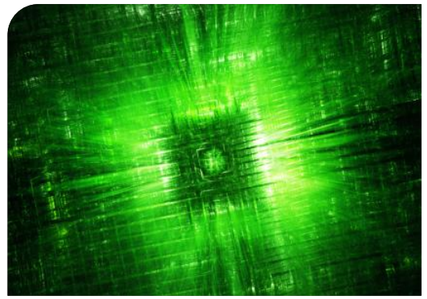
Synchrotron

precision motion control



Semicon

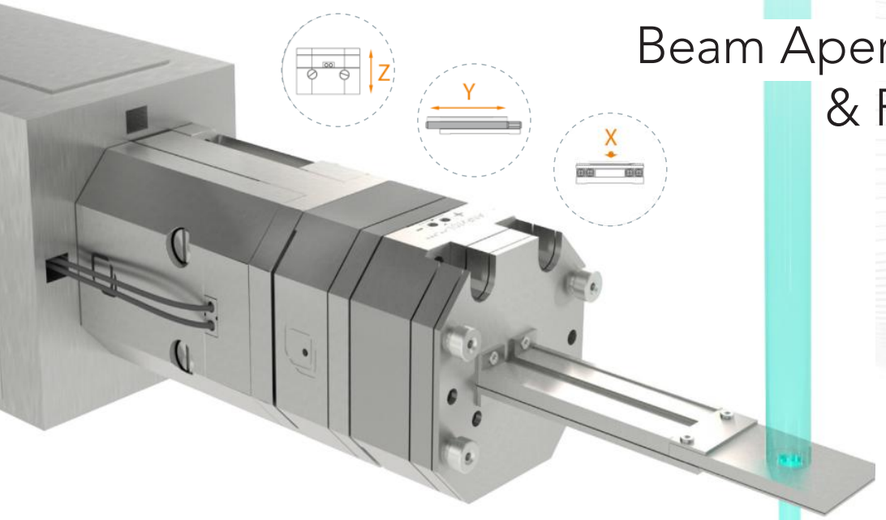
ultra-high precision components

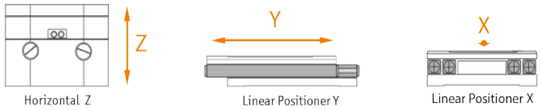


Quantum Optics

reliable and precise positioning

Beam Aperture & Filter Positioning





Horizontal Z | Linear Positioner Y | Linear Positioner X

Challenge:

In lithography and metrology processes, the precise alignment and filtering of the beam is directly related to the wafer´s quality. The laser beam produces photons that are collected via a gathering mirror and directed via different apertures to hit, e.g. the reflection mask.

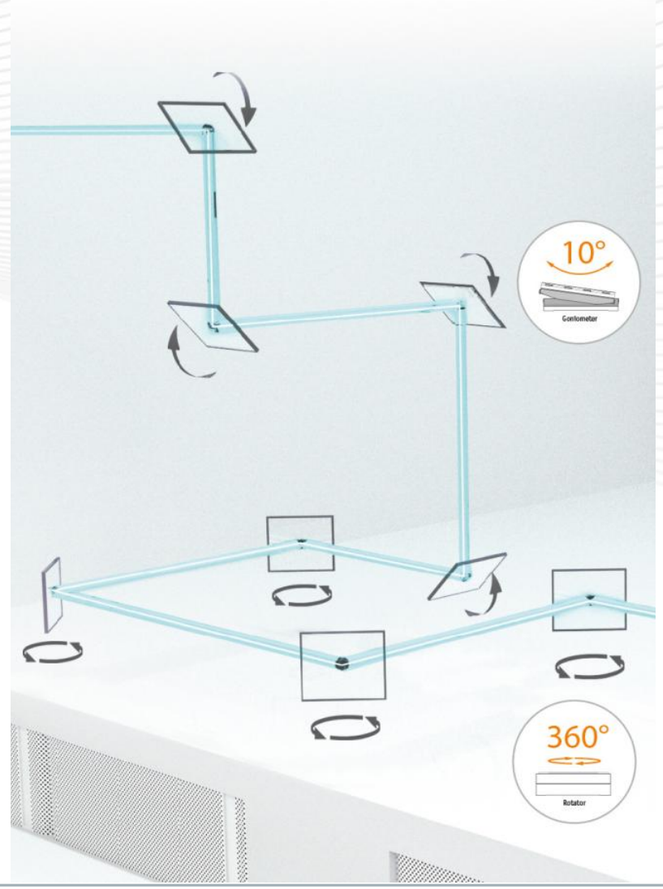
attocube´s solution:

attocube´s nanopositioners are designed to operate with low particle generation at high temperatures and vacuum with nanometer precision. These features make them the perfect choice for reliable aperture control under extreme conditions.

Benefits:

- nanometer precision
- UHV compatibility down to 5 x 10^{-11} mbar
- coarse & fine movement

Laser Beam Adjustment



Challenge:

During the metrology process in the wafers production the light or laser beam path have to be precisely and continuously adjusted to perform the relevant controls over the whole wafer surface in order to detect imperfections and provide certain results on the wafer´s quality.

There are different kind of inspections: Unpatterned wafer inspection where the goal is to identify particles and pattern defects and link those to a specific position on the wafer. Patterned wafer inspection which identifies geometry imperfections via the comparison with a “golden” dye and lastly the reticle inspection which helps to identify single defects on a wafer reticle. This last inspection is usually performed by using UV illumination.

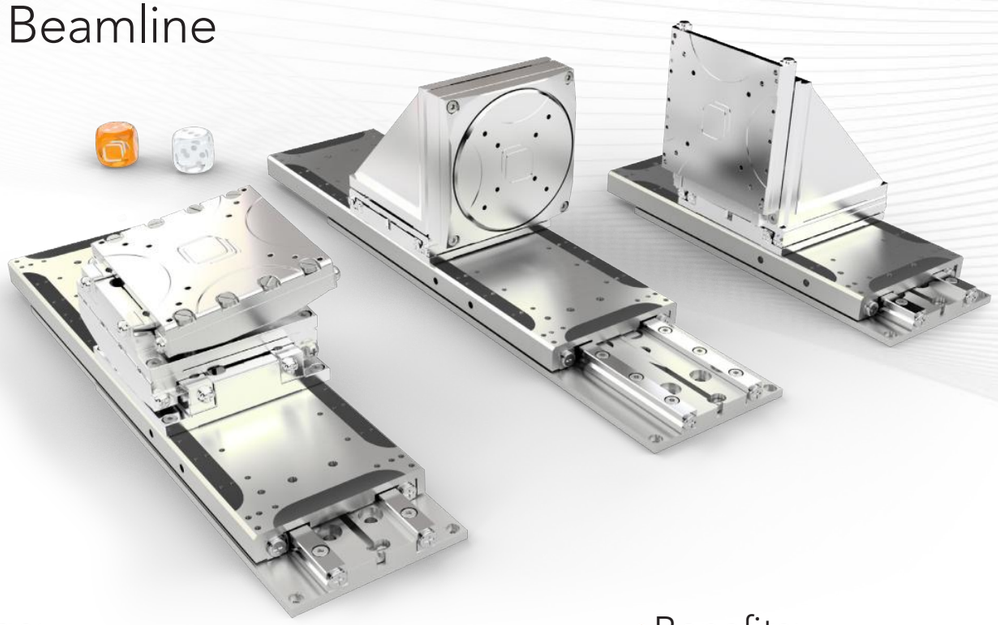
attocube´s solution:

attocube´s nanopositioners are used in critical, ultra-precise motion applications due to the superior accuracy, repeatability & resolution. These unique features together with high reliability are providing a solution for a continuous and stable beam alignment within the metrology process.

Benefits:

- high stability
- goniometer resolution 1 µ°
- rotator resolution 10 µ°

Sample Motion Control in the Beamline



Challenge:

Experiments at large-scale facilities often require beamlines which offer flexible and accurate positioning options. Multiple stages carring different optical components or samples are being moved in and out the beam repeatedly. Therefore, it is key condition to operate the stages with high speed, but also to fine position the sample with highest accuracy and repeatability with respect to the beam.

Benefits:

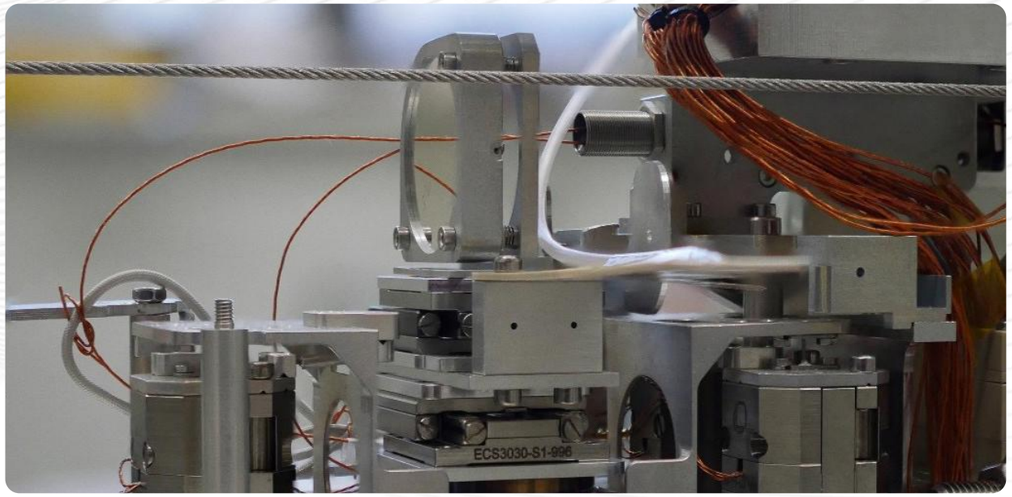
- nanometer accuracy
- extra long travel ranges
- harsh environment compatibility

attocube´s solution:

attocube's positioner portfolio offers multiaxial solutions for these experiments, combining long travel ranges and high speed with maximum precision for coarse positioning. The positioners can be stacked to multi-axis devices and are available for vacuum conditions up to 5 x 10^{-11} mbar.

Synchrotron

Measurements in Synchrotron Radiation



Challenge:

At large-scale facilities, there are a number of generic nanopositioning tasks to be performed under harsh environments such as ultra-high vacuum or radiation. Undulators are the key assemblies for generating synchrotron radiation in light sources. In order to optimize the resulting photon energy, the magnetic properties of cryogenic undulators need to be characterized precisely at different temperatures by movable Hall probes.

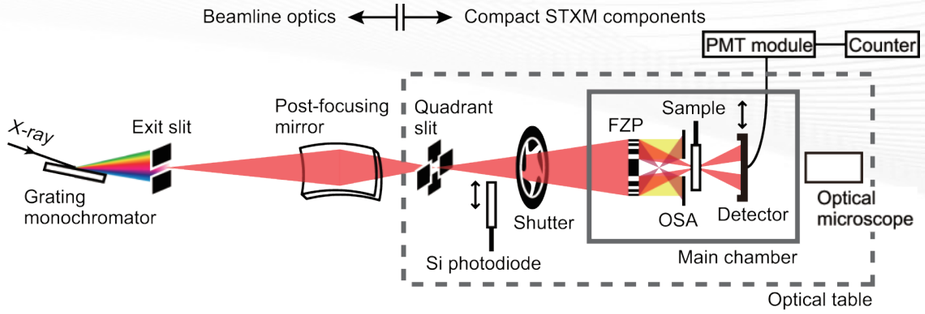
Benefits:

- high size flexibility
- radiation compatibility
- high stability

attocube´s solution:

attocube´s positioners can be combined for multidimensional configurations, and are compatible with variable temperatures, high magnetic fields and radiation. In this particular example, the nanopositioners serve as key elements of the Hall bar bench achieve the necessary accuracy of the Hall-probe orientation relative to the undulator´s magnetic axis.

Portable X-Ray Microspectroscope



Challenge:

In order to perform microscopy and spectroscopy experiments achieving image resolution at the nm level it is necessary to control and maintain temperature, humidity and pressure as stable as possible over time. Mounting a complete system into a controlled environment is often limited by the dimension of the setup itself. Therefore, it is necessary to minimize the footprint and enhance the instrument performance to achieve a nanometer resolution.

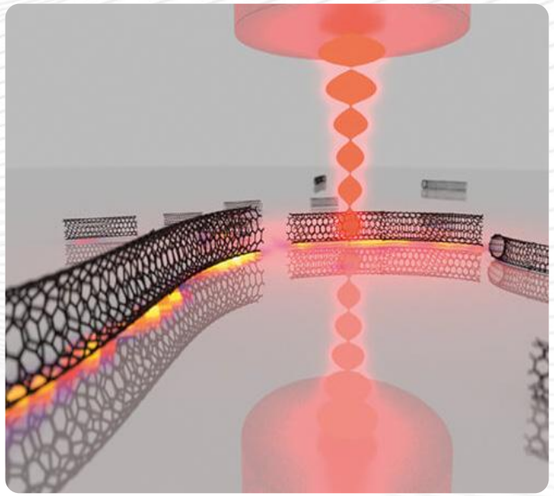
attocube´s solution:

A combination of small sized piezo positioners and scanners provides the necessary millimeter travel range for alignment and imaging the sample with the required resolution. Using a laser interferometer as feedback allows the customer to monitor the motion with a resolution of 1pm ensuring nanometer precise closed-loop positioning.

Benefits:

- nanometer resolution
- harsh environment compatibility (ultra high vacuum or radiation)
- limited footprint of only several square centimeters

Cavity Enhanced Raman Spectroscopy



Challenge:

Raman signals can be enhanced by placing a sample in a microcavity. In order to acquire high-resolution Raman images, ultra accurate positioning of the microcavity is necessary. Each Raman spectrum is contributing to the final step-scanned image. Therefore, the microcavity has to be moved with nanometer sized steps.

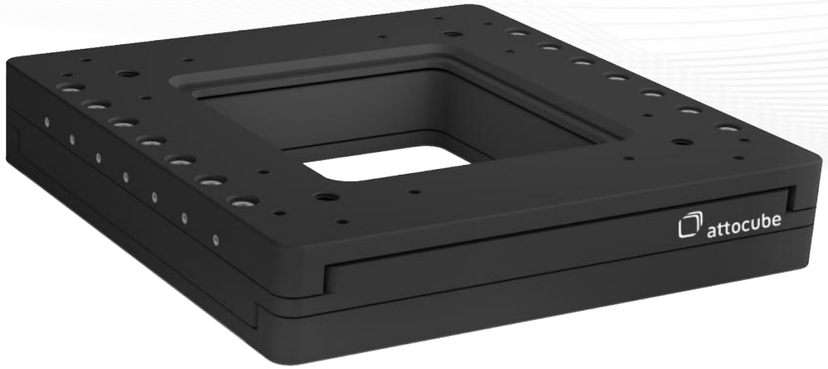
attocube´s solution:

attocube nanopositioners combine movements over millimeters with nanometer accuracy. Typical samples are of the millimeter size. Hence it is possible to navigate and find a micrometer sized region of interest, perform there step scans with nanometer step size, and thus create high-resolution images.

Benefits:

- accurate movement on different scales: millimeter – micrometer – nanometer
- coarse & fine movement
- step size in the nm-range

Positioners for Microscopy



Challenge:

Target motion in optical imaging requires fast and highly accurate sample positioning. The relative and precise positioning of samples with respect to an objective or probe head such as an AFM cantilever is a key condition for reliable and reproducible measurement results.

Benefits:

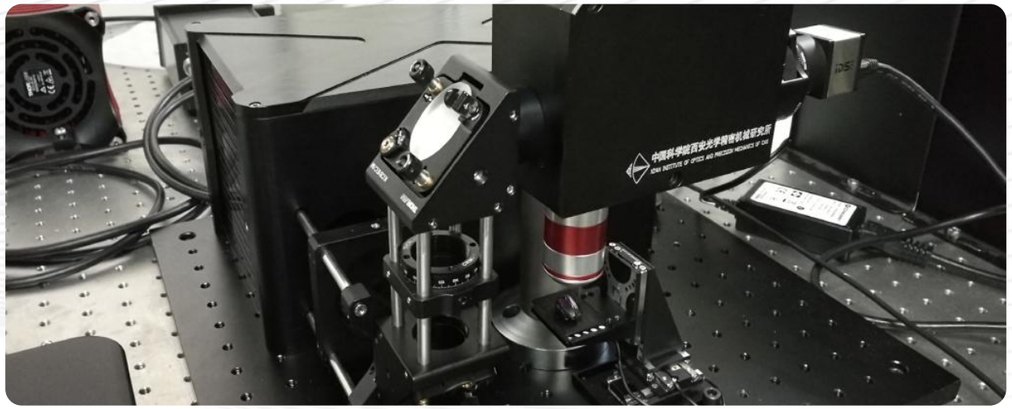
- velocity > 25 mm/s
- repeatability < 50 nm
- monolithic

attocube´s solution:

attocube´s customizable monolithic xy microscopy stage offers highest precision motion on the nanometer scale over several centimeter travel range, making it the perfect solution for OEMs in the microscopy sector. Furthermore, this piezo driven stage offers high drive velocity (up to 25 mm/s) combined with a bi-directional repeatability of better than 50 nm.

Microscopy Application

3D Imaging System



Challenge:

Optical studies in life science typically require investigating samples over cm ranges with sub-micrometer resolution. In addition, fast acquisition times are a key requirement to avoid drift and hence blur during the acquisition process. Last but not least, high position repeatability enables precisely retrieving regions-of-interest and navigation on known samples.

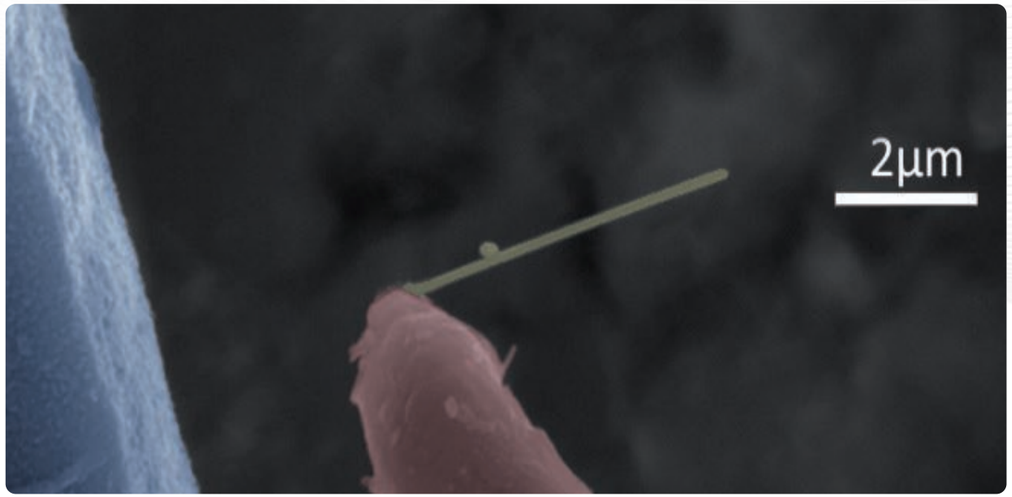
Benefits:

- high stability
- resolution 1nm
- repeatability 50 nm

attocube´s solution:

attocube´s ECS series are used to move and align the sample under the microscope. Thanks to the ultraprecise motion, superior resolution (down to 1 nanometer) and repeatability (50 nm), the nanopositiners are perfectly suited for these applications providing the necessary stability to avoid scattering and blur images.

Micromechanical Testing on Silver Nanowires



Challenge:

The small specimen size often imposes significant difficulties for preparation and testing. This challenge can be overcome with a micro-electromechanic system that allows mechanical testings on nanowires. The possibility to develop such system passes also through the micromanipulation of the nanowires with a nanometer precision.

Benefits:

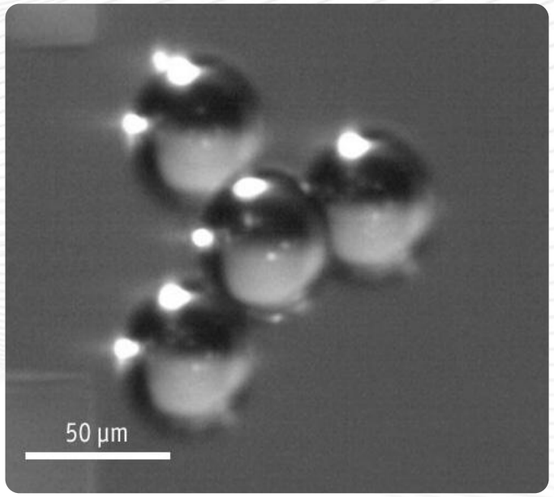
- nanometer accuracy
- vacuum compatible
- stackable positioners (up to 6 degrees of freedom if required)

attocube´s solution:

A stack of 3 ECS piezo positioners allows the micromanipulation of the nanowires in 3 different axis (XYZ) ensuring nanometer repeatability in order to perform simultaneously four point electric measurement by enabling the piezo-resistivity via a micromechanical testing system.

Nanoprecise Positioning

3D Micromanipulation with haptic feedback



Challenge:

Extending human touch with a haptic interface to enable manual exploration and manipulation of micro and even nanostructures is one key goal for robotics on small scales. In this example, precise movement of 10 – 100 µm large objects in 3D space, and a high degree of stability of the positioning setup is required. Furthermore, any external noise to the haptic device has to be below the feedback in the µN-range of the sample.

Benefits:

- smooth movement
- high accuracy positioning readout
- programmable functions through .vi and .dll

attocube´s solution:

attocube nanopositioners perform nanometer sized individual steps in three dimension. The small step size is suitable for macroscopic movement when performed at a high repetition rate. Meanwhile, each individual step is only a tiny disturbance to the microgripper of the sample due to the differences in size of three orders of magnitude.

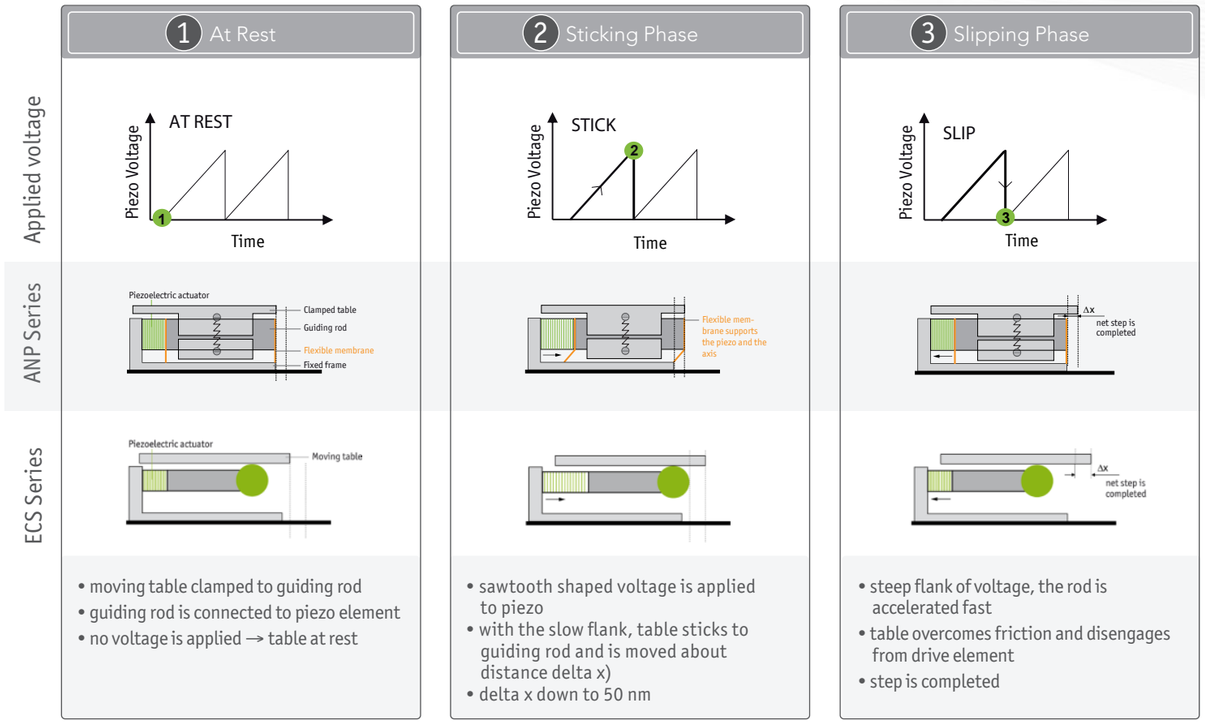
Scanners and Stepping Positioners

All attocube scanners and stepping positioners are driven via piezoceramics made from lead zirconite titanate (PZT) for voltages < 150 V. The PZT for cryogenic scanners and steppers is optimized for maximal performance under these conditions.

- **Scanners**
  Scanners are suitable for travel ranges in µm range and their motion is continuous. Our scanners are recognizable by the name „ANS“.

- **Stepping positioners**
  Stepping positioners are suitable for travel ranges in mm range. They are driven via slip-stick principle (sawtooth voltage). There are two different positioner series – “ANP” and “ECS”.

Working Principle of Stepping Positioners



- moving table clamped to guiding rod
- guiding rod is connected to piezo element
- no voltage is applied → table at rest

- sawtooth shaped voltage is applied to piezo
- with the slow flank, table sticks to guiding rod and is moved about distance delta x)
- delta x down to 50 nm

- steep flank of voltage, the rod is accelerated fast
- table overcomes friction and disengages from drive element
- step is completed

Environmental Conditions

attocube’s nanopositioners can be used in different environmental conditions such as ultra-high vacuum. One or more suitable suffixes in the article name describe the environment for which a nanopositioner is designed and tested in-house. Moreover, all ANP nanopositioners are suitable for measurements in a magnetic field as they are built of completely non-magnetic materials.

- **/RT – Room Temperature**
  /RT positioners are manufactured for use at ambient conditions (room temperature, dry atmosphere, ambient pressure).

- **/(U)LT – (Ultra-) Low Temperature**
  These positioners are suitable for repeated cooling and operation in cryogenic temperatures.

- **/HV – High Vacuum**
  At attocube the high vacuum range is specified down to 10^{-8} mbar.

- **/UHV – Ultra-High Vacuum**
  The ultra-high vacuum range is specified down to $5x10^{-11}$ mbar for most of our positioners. A few rotators and goniometers use UHV compatible grease. Due to the increased outgassing of these types at elevated temperatures we specify them for 10^{-9} mbar as a precaution (noted in specification sheets). Most of our positioners can be baked out up to 150 °C.

Position Control

Most of attocube’s nanopositioners are available in open and closed loop versions.

- **Open Loop Positioning**
  In this mode, the positioner is simply driven forward or backward, without an encoder to read back the actual position or a feedback loop to control the desired target position.

- **Closed Loop Positioning**
  Positioners with an integrated encoder (/RES, /RES+ or /NUM, /NUM+) can be used for closed loop position control. A feedbackloop integrated into the control electronics minimizes the difference between target position and actual position. Setpoints can either be defined in a software interface or on the front panel of the electronics.

- **Resistive Encoder (/RES)**
  A Resistive encoder (/RES) is used for our ANP nanopositioners. The working principle of this encoder type is based on a potentiometer. It is the method of choice for applications at cryogenic temperatures, ultra high vacuum and highest magnetic fields. The /RES encoder measurement refers to the absolute sample position, for most linear steppers a repeatability of 1 µm is achieved. For ultra low temperatures (T < 1 K) a special /RES+ sensor is available which is included in all our /ULT models.

- **Optoelectronic Encoder (/NUM)**
  The usage of a glass grating and the interpretation of the generated Moiré pattern characterizes the working principle of the /NUM and /NUM+ encoder. The measurement refers to the relative sample position with a position resolution of 1 nm and a repeatability of typically 50 nm for most linear stepping positioners. An absolute position information is also available via a reference mark. The +-version /NUM+ features a reduced thermal dissipation of only 50 mW making it especially suited for /HV and /UHV positioners. The /NUM and /NUM+ encoders are available for our ECS series positioners.

Terminology

glossary

Resolution

The measurement resolution is the smallest increment of displacement that the sensor can show.

Accuracy

Accuracy is the deviation of a device's measured displacement value compared to the true displacement of the target. Accuracy is defined as a percentage of the measured range.

Repeatability

Repeatability is the standard deviation (σ) of a set of a device's moving target approach measurements, all made under the same conditions.
Approach measurements may be done from one or both sides of a target, specifying a devices uni- or bi-directional repeatability respectively.

Noise

Noise is the standard deviation (σ) of all additionally captured random values made during any static or dynamic ongoing measurement at a specific bandwidth.

Stability

The stability is the change in bias over time.

Precision

The precision is the standard deviation (σ) of a measurement. Its value is strongly related to the system's noise level, its repeatability and – over duration – its stability.

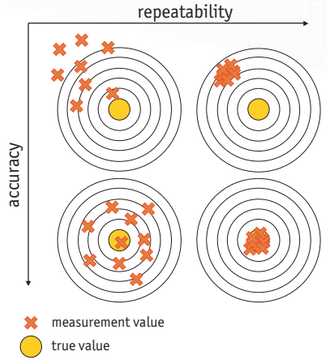


Figure 1: Difference between measurement accuracy (trueness) and measurement repeatability.

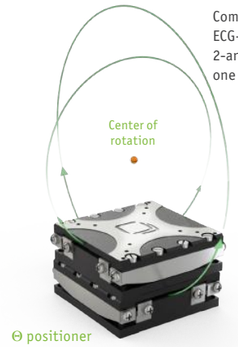
Maximum load

Maximum normal load refers to the maximum amount of weight or force applied perpendicularly to the center of the mounting surface that a positioner can bear without damaging its structure. The positioner needs to be mounted in the intended orientation. Loads around the maximum may influence other specifications.

Combining Goniometers

Each size of goniometer is available in two versions which are usually used as a pair for theta (Θ) and phi (Φ) motion. The Θ positioner mounted on top of the Φ positioner forms a tip-tilt stage with a common center of rotation. Mounting is done directly via two or four screws.

Combinations with other positioners are explained above respectively in the accessories sections on our webpage.



Combination of two ECG-goniometers for 2-angle alignment with one center of rotation

Φ positioner
ECGp5050

Θ positioner
ECGt5050

Dynamic force

This is the force generated by a positioner during its movement along its axis. It is the force that is required to overcome friction and inertia, and to accelerate the device. For positioners that move masses against gravity or against external forces, this property is sometimes referred to as lifting or pushing capability.

Dynamic torque

This is the torque generated by a rotary positioner (rotators and goniometers) during its movement around the rotation axis specified. For positioners that rotate masses against gravity or against external inertia, this property is sometimes referred to as lifting or pushing capability. Please note that the moment of inertia that can be induced by a non-centered load on the positioner has to be considered as a significant factor when accelerating with positioners.

Holding force

This is the force that a positioner inherently applies maintaining its static position along its axis, even in the absence of an external force or respectively also when powered down. The self-locking mechanism is a main advantage of piezo slip stick inertia drives. In general, the holding force is higher than the dynamic force of a positioner. The holding force is sometimes referred to as the static force.

Holding torque

This is the torque that a rotary positioner (rotators and goniometers) inherently applies maintaining its static position around the rotation axis specified, even in the absence of an external force or respectively also when powered down. The self-locking mechanism is a main advantage of piezo slip stick inertia drives. In general, the holding torque is higher than the dynamic torque of a positioner. The holding torque is sometimes referred to as the static torque.

Standard ECSxyz-configuration:
two x-positioners (one rotated by 90°) and one additional x-positioner mounted vertically on a L-bracket.

Additional Info

glossary

Merge Nanopositioning Stages to Multi-Dimensional Systems

The modular concept of attocube positioners in combination with a consequent use of similar mounting patterns enables the assembly of multi-axis positioning units composed of (several) different types of nanopositioning stages. By merging several positioning units with distinct travel ranges and motion options, motor assemblies with up to six degrees of freedom can be built.

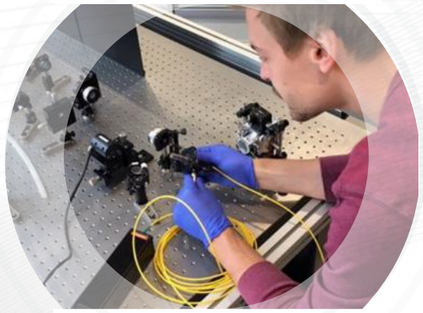
Cross mounting rules

Following general rules apply for building multi-dimensional setups:

- a positioner with a lower number should not be used to support one with a larger number, e.g. an ANPx51 should not carry an ANPz101.
- cross-mounting between two differently sized models (e.g. a 51 series positioner on top of a 101 positioner) may necessitate an adapter plate (see adapter plates overview in accessories section on our webpage).
- all bearing-based positioners (ANPx3*1 series) can be mounted on a L-bracket which enables vertical positioning with loads corresponding to the specified dynamic force for the respective positioner.

Services

how can we support you?

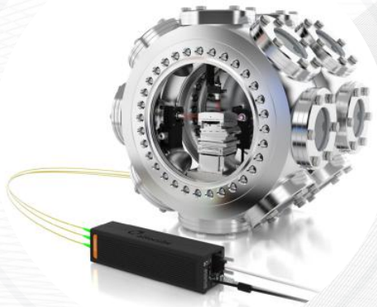


• Application Engineer Integration Program

attocube supports you to start your project with the best technical knowledge on our products enabling you to perform your experiment with the best output from day 1. Our engineers are available to bring your team through the initial challenges and enhance the experience and time-to-result.

• Test Measurements

Is your lab engaged with other experiments and you don't have capacity to test your samples? Do you want to optimize your resources and time? attocube provides the facility and the service to deliver reliable test results and reports directly to you.



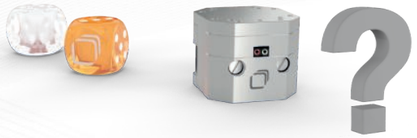
• Application Engineer Initial Training

How to integrate our positioners into your system? Which challenges need to be solved to have them perform at their best? attocube engineers come to your site to provide the best support to integrate our products into your system and efficiently bring your business to the next level.

• Positioners Loan Kit

Do you want to verify if your setup performs at its best with our positioners? The Loan Kit with standard 6D positioners is the perfect solution to test our piezo positioners performance directly at your facility and have a first impression on the precision and the simplicity of our system.

FAQ?



What is the difference between the ANP series and the ECS series?

- The ECS series is a dedicated industrial series which is bearing based, cost efficient and convinces with a rugged design and high load capacities. The ECS/RT models are made out of aluminum and the ECS/(U)HV out of stainless steel. The ANP series is more research focused with smaller footprints and a nonmagnetic positioner body out of titanium.

What is meant with "open loop" and "closed loop"?

- The positioners without an encoder are driven in "open loop" - those positioners can only be driven forward or backward without an actual readout of the position. Whereas the positioners with an /NUM or /RES encoder are driven in "closed loop" mode, which means that a feedback loop integrated into the control electronics minimizes the difference between target position and actual position.

What is the difference between NUM and NUM+?

- The NUM+ encoder features a reduced thermal dissipation of only 50 mW making it especially suited for /HV and /UHV positioners. The necessary amplifier has been detached from the sensor itself and placed in the connector of the cable outside of the vacuum chamber.

Is the controller included with the purchase of a positioner? What else do I need?

- A motion controller is not included with the positioner. attocube's sales engineers help you to find the suitable motion controller as well as cables. Moreover, there are different kinds of accessories like feedthroughs or adapter plates.

What is the difference between the /HV and /UHV positioners?

- For the /UHV positioners special UHV compatible (i.e. not outgasing) materials are used. Moreover, a test in a baked out UHV environment is performed for all UHV positioners to guarantee full functionality usually down to $5x10^{-11}$ mbar. Please note, our ECS series rotators and goniometers are specified for 10^{-9} mbar due to a special UHV compatible grease.

What is the temperature range for the positioners? Are they bakeable?

- All attocube open loop positioners and all closed loop positioners of the ANP series (/RES & /RES+) are specified from 0°C to 100°C (dedicated low temperature positioners are specified down to the mK range). ECS positioners with a /NUM encoder work up to a temperature of 50°C (/NUM+ up to 55°C). All UHV positioners can be baked out up to 150°C.

What is the load capacity in a specific environment or mounting direction?

- All positioners are specified at ambient conditions. For specific requests please contact attocube's sales engineers.

There is only limited space available for my setup, are there positioners with a comparatively small footprint?

- Yes, the ANP series positioners all have a relatively small footprint starting at 15 x 15 mm.

What is the difference between accuracy and repeatability?

- Please refer to the glossary.

attocube
WITTENSTEIN group

attocube systems AG | Eglfinger Weg 2 | 85540 Haar | Germany
Tel.: +49 89 420 797 - 0 | info@attocube.com
www.attocube.com

Brochure version: 2023 - 01