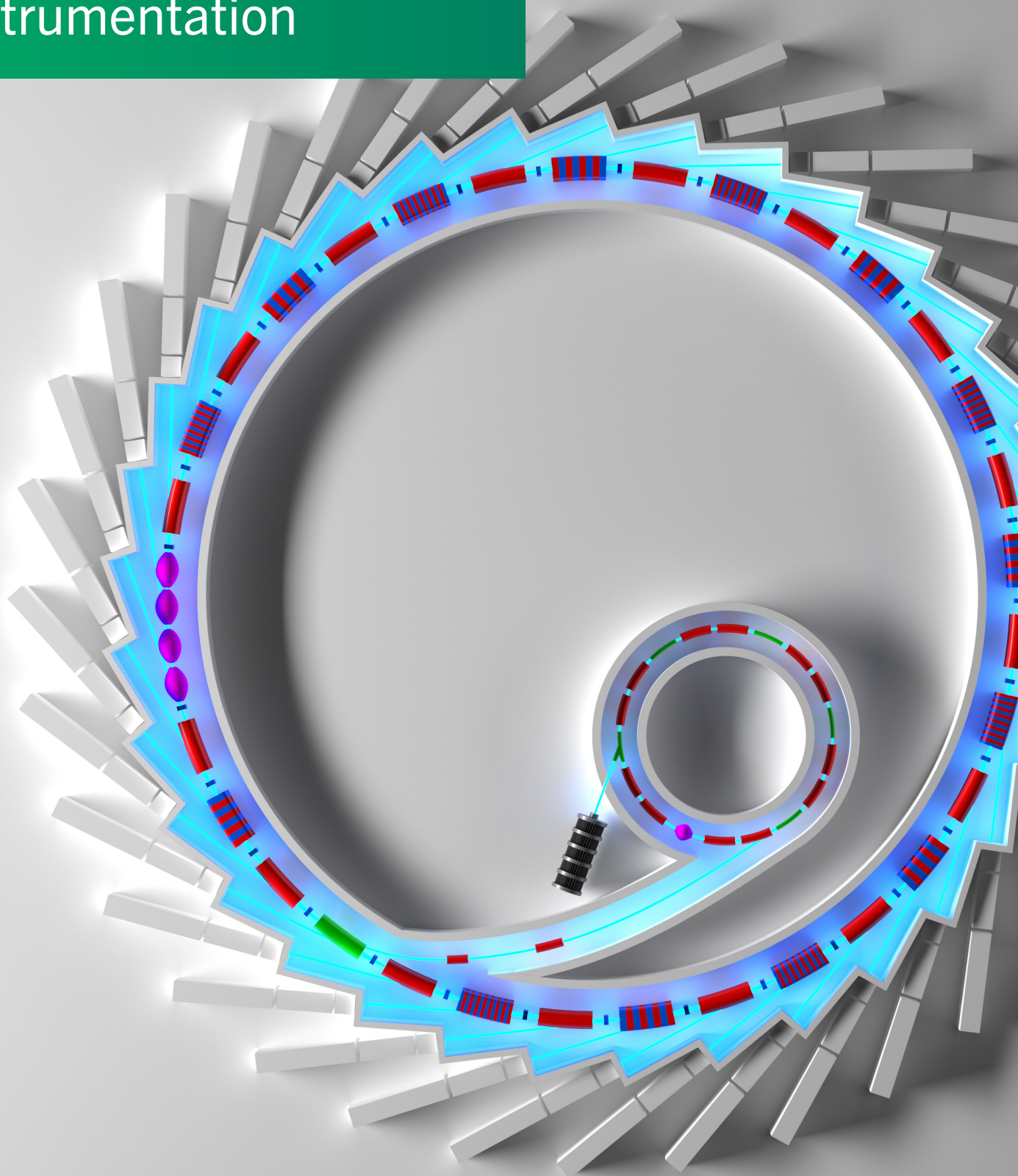


Nanopositioning for beamline instrumentation



Solutions for beamlines

Positioning accuracy for beamline applications

Synchrotrons harness the power of electrons producing intense beams of X-rays, ultra-violet and infrared light. Super microscopes use this light to study anything from fossils to jet engines to viruses and vaccines.

Synchrotron engineers and beamline manufacturers need components capable of operating in an ultra-high vacuum (UHV) environment and may need radiation hard, non-magnetic components with the ability to perform at cryogenic temperature. After installation, system reliability is essential as the beamline is only accessible for short shutdown periods throughout the year.

Synchrotron light is produced as the electrons change direction, the radiation branching off the storage ring, to enter laboratories or beamlines.

Main parts of a synchrotron

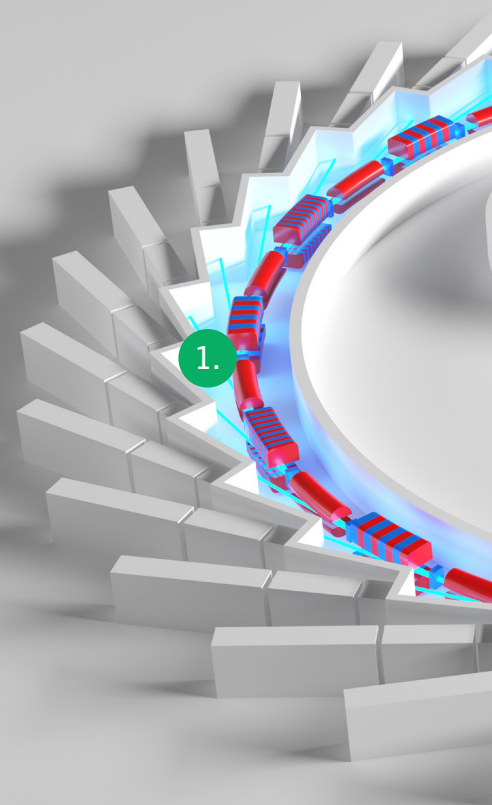
1. Main synchrotron storage ring
2. Linear accelerator (linac) and booster ring
3. Electron gun
4. Beamlines/ experimental stations

High performance, high speed and extreme reliability

Queensgate offers an extensive product line of UHV compatible sensors, piezo actuators, and piezo stages. Whether standard or custom, our systems typically deliver decades of reliable performance, minimizing downtime.

Vacuum preparation

Parts that need to operate in UHV must have low outgassing. Queensgate sensors all use Kapton-insulated wires, and all bonding agents are selected using the NASA outgassing database. All systems are ultrasonically cleaned to remove oils and carbon residue from any metalwork, and system bake-out to remove any solvent residues before installation is recommended.



What distinguishes Queensgate



Performance

The experts in high speed, high precision applications



Experience

Over 40 years of delivering performance-critical components



Enhanced control technology

A tool kit to deliver the best performance for the application



Design

Material selection and FEA design to meet the demands of synchrotron applications



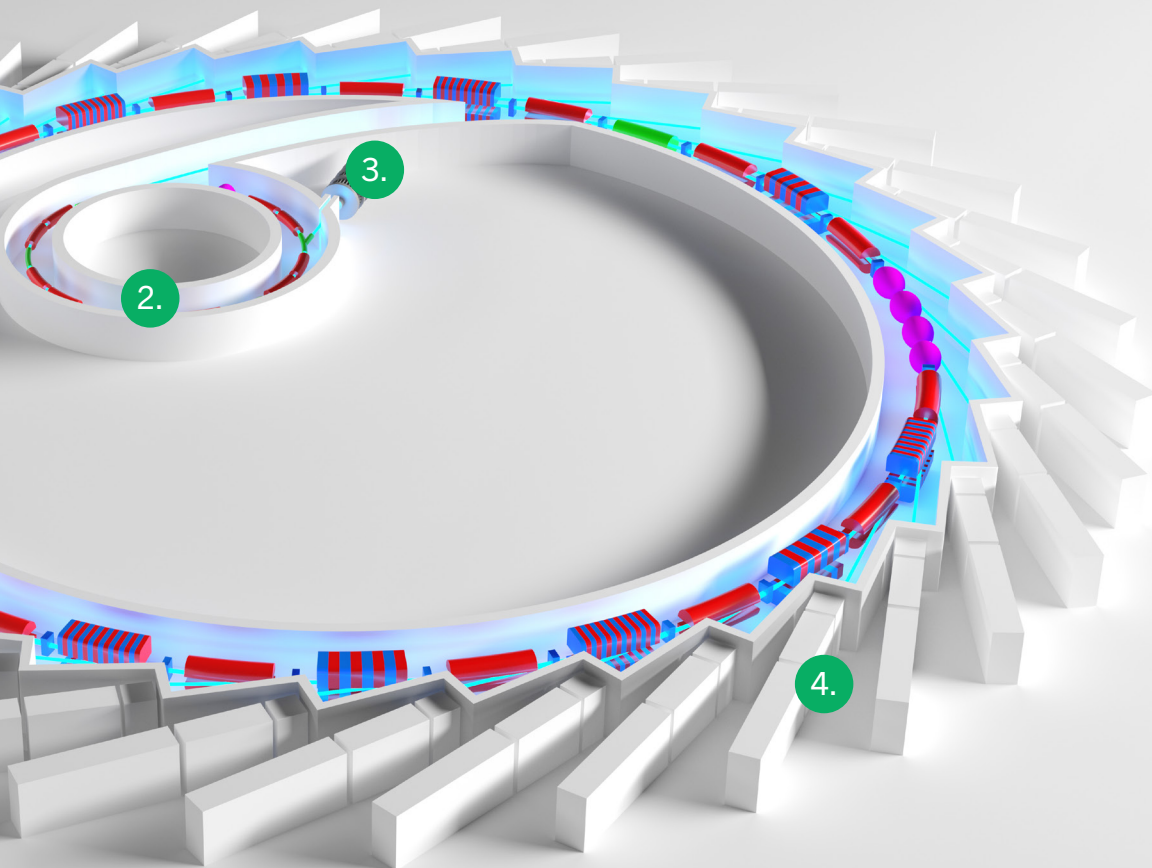
Reliability

Trouble free installation in beamlines over decades of use. Plug and play electronics.



Custom solutions

over 70% of our products are custom made



Piezo stages and actuators

Diversity of applications

Queensgate flexure-guided piezo-actuators position optics, lasers, samples, and monochromators with picometres of resolution. All Queensgate stages and closed-loop actuators incorporate capacitive positioning sensors for the best positioning performance and are also available as vacuum compatible versions.

Plug and play

All closed-loop stages and actuators use plug and play technology. The calibration and reference sensors are held in an EEPROM in the airside cable connector. This allows control units to be interchanged for diagnosis and repair while the mechanism is under vacuum in the beamline maintaining system performance.

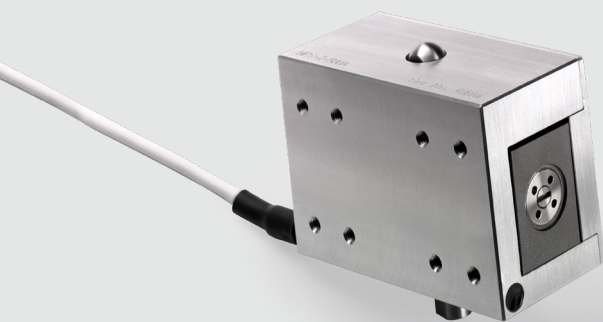
APPLICATION

Silicon crystal bending in a beamline monochromator

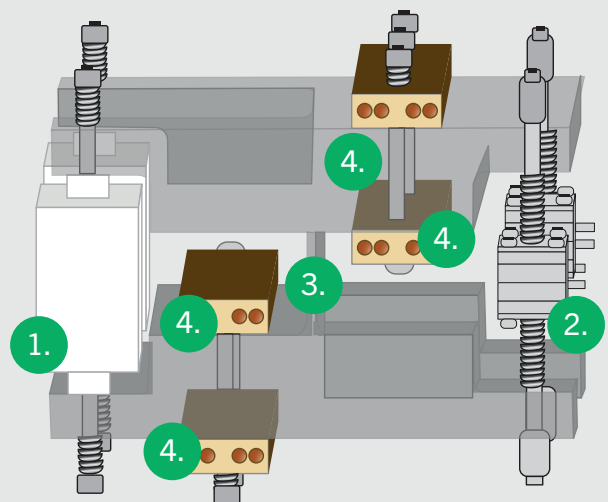
A pair of NPS-Z-500B-UHV-RAD closed loop piezo stages operating independently apply force to a silicon crystal in a Bragg monochromator. Queensgate capacitive sensors (Nanosensor™) NXD2-AL-UHV-RAD are used to measure the position of the crystal and provide feedback to the stage.

“It is stable, doesn't vibrate or shake and is happy working in a high radiation environment.”

Principal Beamline Scientist, I12 JEEP High Energy Beamline at Diamond Light Source



NPS-Z-500B-UHV nanostaging stage
Radiation hard and operates to 10^{-9} Torr at 80° K

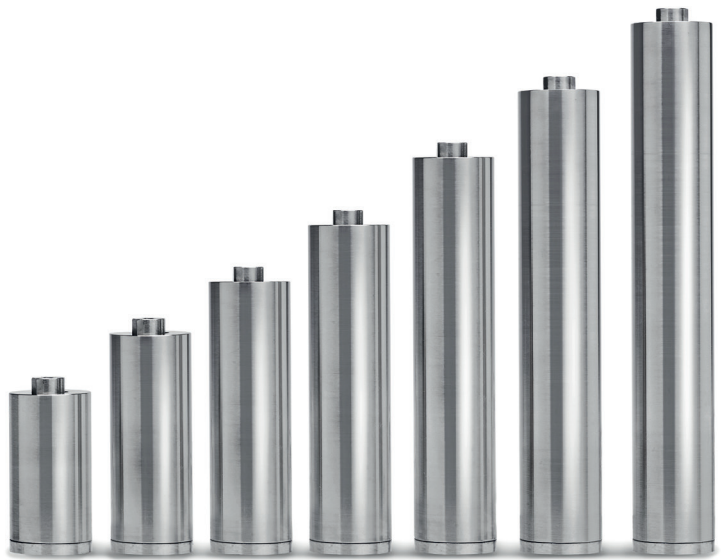


Two NPS-Z-500B-UHV actuators (1) apply force to a silicon crystal, the deflection is measured using NXD2-AL-UHV-RAD capacitive sensors (2). Light area (3) is maximum of 91 x 3 x 25 mm and thermal Load is 840 W. Liquid nitrogen pipelines (4) keep the system at a maximum temperature of 150° K.

This allows the two actuator systems to finely adjust the force in order to avoid twisting the crystal. The resolution required is 2-5 nm and the range required is 100 μ m. The system was designed to operate at cryogenic temperatures (80° Kelvin), in vacuum (to 10^{-9} Torr) with a maximum equivalent dose of radiation within the beamline of 143 Sv/h. The NPS-Z-500B-UHV is an upgraded version of the system for I12 JEEP High Energy Beamline at Diamond Light Source.¹

DPT actuators – precision, speed and reliable performance

Queensgate DPT actuators are in use in a variety of beamline applications across the world. They are the only actuator using capacitive feedback control, giving a positioning resolution ten times better than other available systems. Other benefits include precise positioning and capability of moving loads >60 kg over the full travel range.



APPLICATION

Fine adjustment and vibration compensation

Third-generation synchrotron light sources produce high brilliance X-ray beams. Vibrations may degrade the electron beam's centre of mass stability, dramatically reducing the brilliance. Sources of vibration within the synchrotron include circulating pump circuits for cooling synchrotron components, UHV systems, electrical power plants, and moving personnel. Queensgate closed loop piezo actuators operate at high bandwidths to provide high precision position adjustment to compensate for the external vibration.

Decades of use

A Queensgate Instruments controlled piezo feedback system was installed on the second crystal on the macromolecular crystallography MAD beamline ID14-4 at the ESRF. It proved to be the single most important device that allowed ID14-4 to routinely operate, and it provided a decade of operation on the macromolecular crystallography MAD beamline at the ESRF.²

APPLICATION

Moving high loads with precision

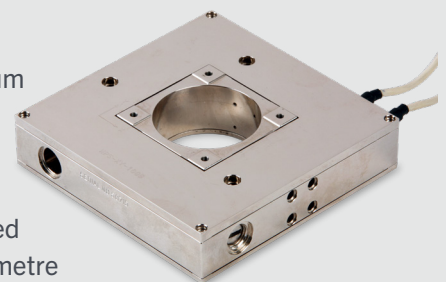


Originally produced as a custom actuator, the NPS-Z-15L-UHV has very high stiffness of 1000 N/ μ m, blocking forces of up to 35,000 N, and can move loads of up to 500 kg. The very high stiffness with high positional stability is ideal for aligning or leveling large optics and monochromators, minimizing vibration.

APPLICATION

Vacuum compatible stages

Most Queensgate stages can be produced as vacuum compatible systems. The QGNPS-XY-100A-UHV operates down to 10^{-9} Torr and has 100 μ m closed loop range with sub-nanometre resolution.



Advanced control technology

A tool kit to deliver the best performance for your application

Low noise / high resolution

Queensgate closed-loop piezo digital controllers have low picometres of noise, which is essential for maintaining the integrity of signal over the longer cable lengths required in synchrotron applications. Digital control allows ultra-fine positioning and custom settings for variable loads optimized for speed and resolution.

Easy to interface

All controllers have an easy interface and come with a DLL (Dynamic Link Library) for Windows and Linux. Queensgate's NanoBench PC software is supplied with examples of software in LabVIEW®, C/C++, and Python with USB or optional Ethernet connectivity. You can also choose external analog input/output control of the NanoMechanism position.

Fastest update rates

NPC-D-5200 Digital Controller

The NPC-D-5200 single-channel system has an optional slot for an interface card allowing custom interfacing with external equipment. The controller updates position 120,000 times per second. The custom interface enables external equipment to set the commanded position at the same rate with picometre resolutions.



NPC-D-5200 Digital Controller. A standalone single axis closed loop piezo actuator controller for dynamic performance.

Easy, sophisticated control

NPC-D-6000 series controllers

The NPC-D-6000 range of controllers are available as single and multichannel versions and updates position 50,000 times per second. The 6000 range of controllers includes digital quadrature/step-and-direction commands allowing high-speed control with a standard 2-wire interface allowing integration with stepper motor control systems. Function playback allows pre-programmed waveforms to be downloaded into the controller and played back. These can be triggered from a PC or TTL inputs. Playback may be independent for each channel or synchronized for multi-axis control. TTL outputs can be triggered at any point(s) within the function playback waveform, allowing other equipment to be triggered accurately at locations in a scan pattern.

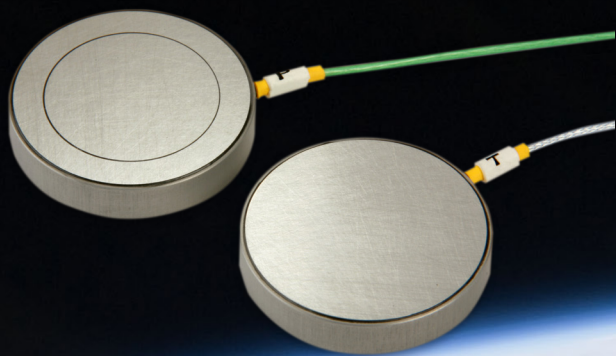


The NPC-D-6000 series controllers deliver repeatability of movement with improved precision and accuracy for precise imaging and focusing at higher maximum speeds with fast step settle times.

NanoSensor™ position monitoring for demanding environments

Position monitoring using capacitive sensors

The NanoSensor™ is a non-contact position measuring system based on the principle of capacitance micrometry. The twin plate design is particularly suited for operation in UHV as the sensor heads are free from electronics. This design delivers superior resolution and linearity, and won't be affected by radiation.



The NX Series of NanoSensor is available in aluminum and Super Invar. Measurement ranges from 20 μm up to 1250 μm are available with frequency responses up to 20 kHz and linearity down to 0.02%. Resolutions as small as seven picometres (RMS) can be achieved. They are non-contact, non-self heating, and maintain their zero position when powered down.

The NC Series is a range of custom sensors providing exceptional reliability in high radiation environments, over a broad temperature range. Sensor housings are application-specific; for example, invar housings provide thermal stability at cryogenic temperatures, and aluminum housings are nonmagnetic.

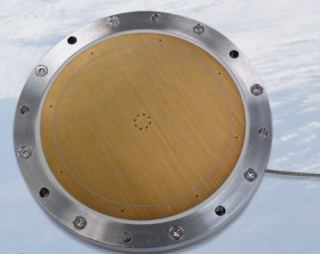
Positioning accuracy and vibration measurement

NanoSensors are used in beamlines to provide metrological measurements for example crystal bending and can be used to measure the relative pitch vibrations within a monochromator.³

APPLICATION

Custom sensors developed for a prototype insertion device

The NC custom sensors are UHV compatible to 10^{-10} Torr, non-magnetic and radiation hard. They can operate over a wide temperature range 80° K to 423° K. The ceramic gold construction removes all adhesive bonding agents allowing 'bake out' at higher temperatures before installation.



As a testament to their reliability Queensgate sensors continue to operate in the robot arms of the International Space Station.

References

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3. Kristiansen, P., Horbach, J., Döhrmann, R. and Heuer, J. (2015). Vibration measurements of high-heat-load monochromators for DESY PETRA III extension. Journal of Synchrotron Radiation, 22(4), pp.879–885.

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