queensgate
a brand of PRIOR

Innovation in nanopositioning



Experts in high speed, high precision applications

Leaders in nanopositioning

Queensgate has been a premier supplier of high precision nanopositioning products for over 40 years. The company was founded in 1979 from the groundbreaking research at Imperial College in London and quite literally "wrote the book" on nanopositioning. The Nano Positioning Book by Thomas Hicks and Paul Atherton defined the stringent use of "precision" and "accuracy." These definitions are still upheld today as the only way to describe nanopositioning systems' performance.

Queensgate's research and product development activities continue to play a significant part in the R&D of a wide variety of industries. In 2018 the company was purchased by Prior Scientific Instruments Ltd.

We deliver what customers need

Most Queensgate products are custom made to meet unique customer requirements. Our agile development team can translate customer needs into high precision devices and provide a competitive advance to customers. Components like nanopositioning stages, piezo actuators, and capacitive sensors can be adapted to fit into OEM machines and production equipment.

Rugged, reliable, and fast

Queensgate systems are the products of choice when sub-nanometer resolutions and the best dynamic specifications are required.

You can find Queensgate systems in demanding manufacturing environments, such as hard disk testing and lithography platforms. Scanning probe, confocal, and super-resolution microscopes also depend on Queensgate products, as do many of the world's largest telescopes, satellites, and even robotics systems on the International Space Station.

Continuous innovation

1979
Capacitive positioning sensors built into piezo positioners

1982
Digital piezo technology

1982
Super Invar actuators

1986
First microscopy products

1996
Super Invar stages

1996
Isostatic mounting

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 highest demands

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

Custom solutions
Over 70% of our products are custom made

> *"We have received what I believe is the best nanopositioner on the market."*
>
> Ron Anderson
> Managing Principal Engineer, Seagate

1996
Digital controllers

2012
Force feedback

2016
Feedforward algorithm allows bandwidths to >40 % of the resonant frequency

2016
Advance plug and play stages

2019
Active damping

2019
Velocity control

High performance from design to manufacture

Designed for performance

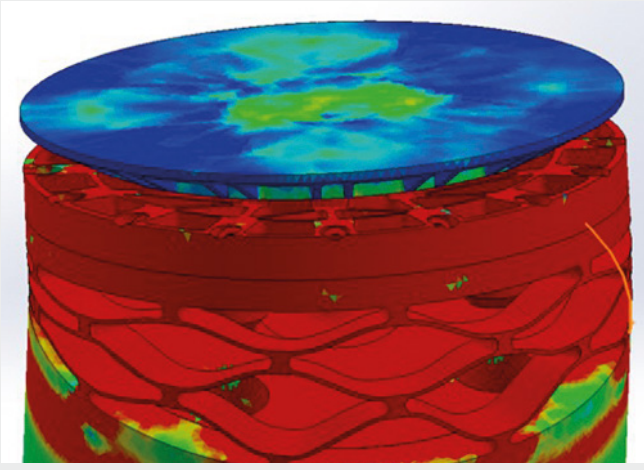
Queensgate specializes in piezo-driven flexure-guided positioning stages, piezo actuators, and capacitive sensors. Most of Queensgate's solutions are customized to meet customers' unique challenges on performance and quality. We have helped our customers to decrease their test times and increase their products' yields by consistently delivering the best performance for the price.

Queensgate engineers use the most advanced computer-aided techniques to predict stage designs' behaviour, select the piezo stack, and choose the right materials to meet unique requirements and specifications.

We road test your product before manufacturing

Queensgate uses Finite Element Analysis (FEA) before physical prototyping. FEA is a method of analyzing virtually how a part or assembly will perform over its lifetime. FEA enables us to design robust and reliable products with quicker development times and reduced development costs.

In this picture, FEA is used to minimize stresses for stage longevity. The photo shows the peak stress in the internal flexure pivot under closed-loop operation for a high-speed positioner to adjust the position of a 100 mm mirror.



Product innovation for maximum performance

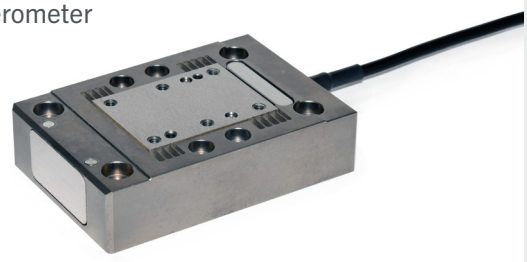


Integral stage flexure hinges

- Amplify piezo motions
- Decouple off-axis motion and strain
- Give pure single-axis motion by preventing movement in the other axes.

High-speed titanium stage for hard drive testing

- Patented flexure designs
- Noise <93 pm measured using an interferometer
- Bandwidth greater than 2000 Hz
- Resonant frequency 5700 Hz



Unsurpassed accuracy and repeatability



Capacitive feedback sensors

Piezo stages operating in open loop have variability in position of between 10 to 15 per cent. For accurate positioning of piezo stages, closed loop control is required using position measurement.

Queensgate pioneered the use of capacitive feedback sensors for closed loop stages and actuators. Capacitive feedback sensors deliver the best positioning accuracy and repeatability (shown in the table below). Our stages can achieve less than 0.01% variability in position.

Benefits of capacitive sensors

- High resolution / low noise
- Stability / repeatability
- Linearity
- Highest bandwidths – speed
- Non-contact sensors are more independent of thermal influences when the stage is in operation – lowest drift.

Comparison of capacitive positioning sensors

	Capacitive positioning sensors	Strain gauge	Piezo-resistive
Resolution	<0.05 nm	1 nm	<0.5 nm
Linearity	<0.01 %	0.5 %	0.5 %
Stability / Repeatability	0.1 nm	15 nm	>15 nm
Bandwidth	10 kHz	5 kHz	5 kHz

Selecting the right materials for the optimal performance

Vigorous material selection is the key to delivering the performance required and manufacturing reliable and robust solutions. Some applications operate in demanding environments, like ultra-high vacuum, high radiation, cryogenic temperatures and may need to be non-magnetic. All these make the material selection an integral part of the product design.

- Material stiffness and density influence the resonant frequency and hence bandwidth.
- Thermal expansion coefficient determines the movement of a particular point on the stage with respect to temperature.
- Loading impacts, the resonant frequency and therefore stiffer material will be required to deliver dynamic performance for higher loads.
- Material strength is also a factor for high loads and durability. Material options include stainless steel, aluminum, titanium, Super Invar.

Enhanced digital control technology

Unparalleled precision with the best dynamic performance

Digital control provides the flexibility of tuning to optimize a system for speed, resolution and payload. Queensgate standard controllers have the lowest electronic noise (low picometres levels) have high power and run closed loop control in 20 µs.

Queensgate stages are often 4 to 5 times faster than competitive stages. They can operate at high bandwidths (3 dB bandwidth) over 40% of resonant frequency while maintaining precision and resolution.



NanoScan NPC-D-6330 series three axis closed loop digital controller

Market-leading performance

Unparalleled speed
Queensgate stages are often 4 to 5 times faster than competitive stages due to advanced control algorithms.

The fastest settle times
Digital control provides the flexibility of tuning to optimize a system for speed, resolution and payload.

Hardware
Low noise allows the best dynamic performance while maintaining high resolution and positioning performance.

Velocity control
High speed imaging for AFM, or using the latest high speed, high resolution cameras.

Flexibility and ease of use

Queensgate digital based servo control systems are designed to be easy to use and easy to interface. Nanobench PC software provides a simple user interface to change or modify settings.

Systems are typically shipped with three factory settings optimized for the stage or application. Additional slots are available and can be populated with customer defined settings or used for further optimization to deliver high resolution and high speed or cope with variable loads. For OEM systems stages are programmed with custom settings during production.

True plug and play

You can easily change controllers. This is especially helpful when access to a stage is difficult, for example, when a stage is embedded in an instrument or operating in high vacuum.

The controller can be driven using analogue inputs or digitally via USB or RS-232C connections. The controller also has step and direction/quadrature inputs allowing it to interface directly with motion control systems. Trigger inputs/outputs are available to interface with external equipment such as cameras.

Marketing leading control algorithms

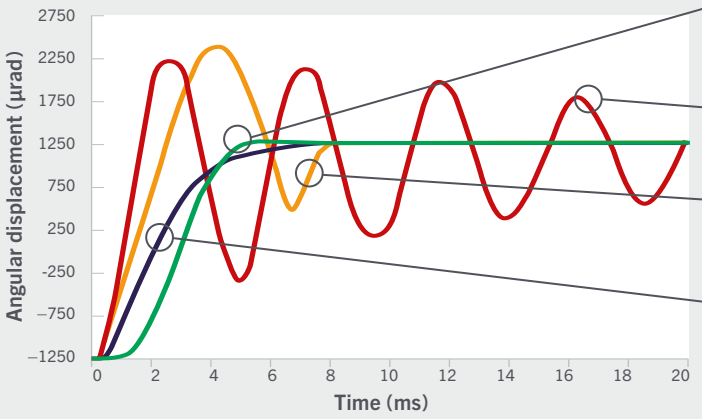
A tool kit to deliver the best performance

Queensgate algorithms control speed and acceleration to minimize overshoot and system resonances to give the best step settle times. User-selectable parameters allow for easy change of key parameters and a range of functionalities for application-specific requirements providing unparalleled flexibility and usability.

Digital control electronics contribute significantly to stage performance.

- High order polynomial linearity functions optimize the linearity of movement for the best positional accuracy.
- Twin notch filters reduce the effect of first and second resonant frequencies on dynamic position.

Queensgate control algorithms compared to standard servo loop (PID) and open loop performance



Queensgate control algorithms reduce the settle time to ~5 ms

Open loop control
The system hasn't settled after 20 ms

Fast servo loop (PID), the step is fast, there is significant overshoot and the step settle is >8 ms

Closed-loop slow PID
On a slow setting there is little overshoot, but again the step settle is ~7 ms

Ultrafast high-resolution imaging

Velocity control allows the stage to operate at a highly stable steady state constant velocity. These ultra-smooth ramps can be used for applications such as raster scanning, focus stacking or focus bracketing.

Function playback allows easy construction of waveforms for use in constant velocity ramps as well as other programmed moves such as S-curve profiles to avoid exciting system resonances, sine waves and more.

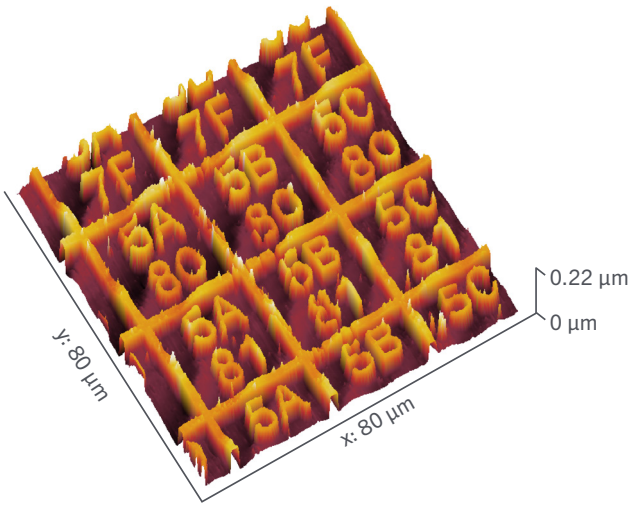


*Image: **High speed, high resolution AFM** image captured in 40 seconds at National Physical Laboratory. 2 mm/s scanning with 250 raster lines over linear area of 80 x 80 µm.*

Designed for demanding environments

Queensgate products have offered decades of use in challenging environments delivering high speed and high precision. Our advanced control technology allows for ultra-fine positioning and trouble-free installation. Our products are designed to work in environments where system reliability is essential, like in space or synchrotron beamlines.

UHV solutions

Parts that need to operate in ultra-high vacuum (UHV) must have low outgassing. Queensgate UHV products all use Kapton-insulated wires, and all bonding agents are selected using the NASA outgassing database. Our UHV options are guaranteed performance to 10^{-9} Torr and are available as radiation prepared variants.

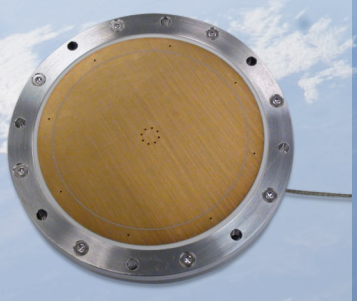
Custom Sensors

- Ultra-High Vacuum (10^{-10} Torr)
- Non-magnetic construction
- Shielding from high electromagnetic interference
- Radiation stability
- Cryogenic operating conditions
- Range (>10 mm)

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.



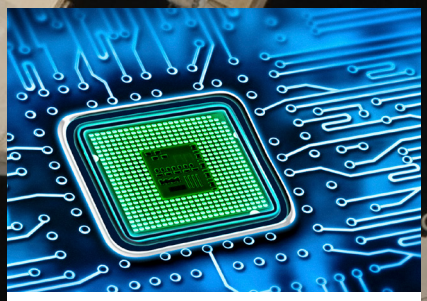
Applications and markets

We pride ourselves on offering our customers robust nanopositioning and nanomeasuring systems that offer picometer resolutions. As experts in high precision, high-speed applications, we deliver solutions for Big Science, semiconductor instrumentation, hard disc testing, and many more.



Hard disk drive testing and grading

Rapid price erosion and vertical increases in demand for high capacity HDD devices has lead to huge demands on existing and new testing, grading and product development tools.



Semiconductor industry

As quality and throughput demands continue to dominate the semiconductor industry, faster and more accurate scanning and measurement equipment is required.



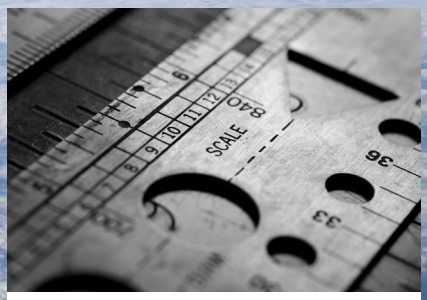
Microscopy, SPM and AFM

Queensgate produces high quality, state of the art nanopositioning stages for microscopy applications. XYZ systems offer the best stability for SPM and AFM applications.



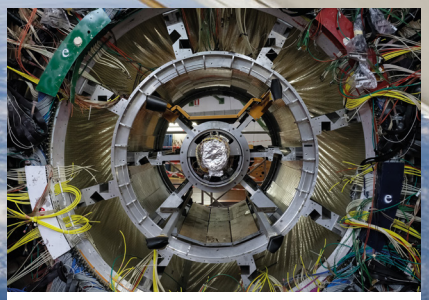
Space, astronomy and military

Nanopositioning solutions for onboard scanning and sensing equipment for space and military applications.



Biotechnology, metrology and optical inspection

Analytical solutions for process and quality control where particle size and particle size distribution help characterise metals and alloys.



Synchrotrons and beamlines

Nanopositioning stages and UHV positioning systems provide solutions for use under high vacuum conditions and where high precision is needed.

Custom design and OEM

Design and manufacturing under the same roof

Queensgate has over 40 years of experience providing custom/OEM solutions where precision, accuracy, and dynamic performance are required. The development process is customer-focused as the engineering teams work closely to understand the customer application and system requirements.

Our in-house team provides world-leading innovation and expertise for those looking to find new accurate and efficient solutions or new applications. The company is ISO 9001 registered, focusing on high quality and project management to meet the performance specification on time and within budget.

APPLICATION

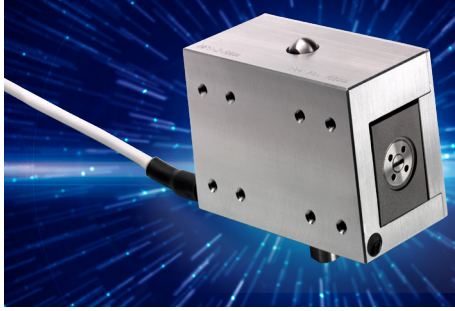
Custom system for hard disk testing

Unique high-speed interface to provide protocol updates 120,000 times per second to servo out any oscillation. 2000 Hz servo loop bandwidth 1 µm step settle to 0.5 nm error within 5 ms. Test and calibration performed with a cantilevered mass; <90 pm noise measured at the cantilever tip with <0.05 % linearity error.



"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



APPLICATION

Crystal bending in high energy X-ray beamline for imaging, diffraction and scattering

Queensgate capacitive sensors (Nanosensor™) NXD2-AL-UHV-RAD are used to measure the position of the crystal and provide feedback to the stage. This allows the two actuator systems to finely adjust the force in order to avoid twisting the crystal. Read more at nanopositioning.com/synchrotrons-and-beamlines.

Product range

Nanopositioning stages

- Piezo-driven, flexure-guided
- Capacitive feedback control to give precise positioning.
- Picometre resolution, repeatability and positional stability.
- Market leading dynamic performance

Single and multiaxis stages



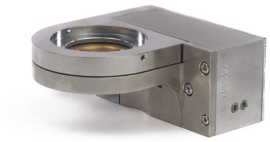
XY stage



X stage

Microscope automation

- Objective positioners
- Z stages



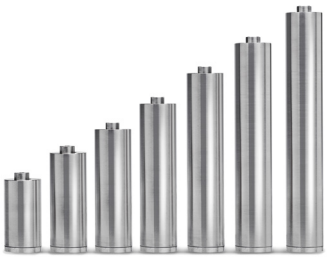
NanoScan OP400 Nanopositioning Piezo Objective Scanner



NanoScan SP400/SP600 Nanopositioning Piezo Sample Scanner

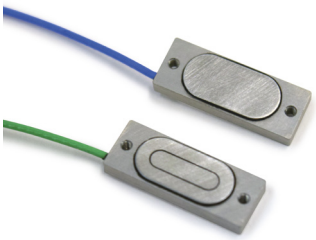
Piezoactuators

- Move loads of up to 60 kg over full travel range at high bandwidths.
- Capacitive feedback control positioning with precision, speed and accuracy.



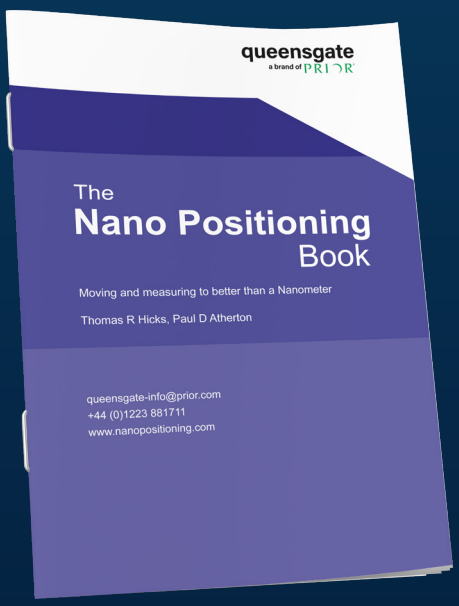
Capacitive sensors

- Providing positional feedback, ranges 20 µm to 11 mm
- High resolution / low noise, 7 pm to 50 nm
- High linearity of movement
- Repeatability <1 nm





To see our full product range, visit:
nanopositioning.com



For more information on our design principles, test, and measurement, download The Nano Positioning Book

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CYBER ESSENTIALS

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