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## Nanopositioning and Precision Motion Control: A Step Ahead

Nanopositioning mechanisms are key to progress in fields as diverse as materials science, genomics, photonics, defense, biophysics and semiconductors. A nanopositioning mechanism is defined as a positioning device capable of nanometer or sub-nanometer resolution. There are several types of nanopositioners; the article covers several new designs, including miniature inertia motors, parallel kinematics, voice-coil drives, frictionless air bearing stages and piezo-driven, flexure guided stages equipped with direct metrology feedback. The pace of innovation in recent years has been blistering.

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Positioning



### Nanopositioning A Step Ahead

It is almost a cliché among students of creativity that innovation occurs at the intersection of fields. Since nanopositioning is a discipline that has enabled wildly evolving application arenas as diverse as materials science, genomics, photonics, defense, biophysics and semiconductors, it's unsurprising that its pace of innovation is nothing short of blistering in recent years.

Scott Jordan, Brian Luo and Stefan Wenzel  
PI Physik Instrumente LP

**B**y its original definition, a nanopositioning device is a mechanism capable of repeatedly delivering motion at increments as small as one nanometer. Lately demands from industry and researchers have driven requirements to 100-nanometer and below.

While electrostatics such as piezo actuators with flexure guides remain the gold standard for limiting the maximum resolution limits, there are several other commercial solutions available today providing repeatable single-digit nanometer repeatability including linear motors, voice coil drives and flexure guides such as air bearings and magnetic bearings.

The recent innovation push both benefits and challenges for engineers and researchers who need to integrate nanopositioning into their applications. Research stage from reduced throughput, precision and accuracy to weight reduction of applications that were formerly impossible. One big challenge is simply keeping up with the same breakthroughs as they become commercially available, and to

reaping the benefits of these without accepting unnecessary technical risk.

Choosing the right nanopositioning system means, ideally, that the vendor understands the complex application, brings best specifications for resolution, accuracy, travel and throughput to the development environment, understands and systematizes needs.

Of course, cost matters – which include not only purchase price but cost-of-ownership – are critical for all parties to understand. Deeply functional, well-documented and robust software support libraries that facilitate rapid application development are increasingly important for accessing advanced functionalities, enabling support users and compressing time to market in today's multi-platform world. Custom solutions are often required, and the vendor's educational, technical depth, global support capabilities, adherence to international quality standards and organizational stability are key to successful long-term partnerships. Capabilities of today's strongest expert control algorithms is also important for many customers.

More and more, dynamic system diagnostic applications, with novel approaches that handle real-time high-dynamics applications. These present new opportunities for optimizing process economics.

In fact, optimization is often the application in a nutshell, for example in the rapid fab-floor testing and packaging of today's new generation of silicon photonics photonic devices. In these applications, optical stresses and profiles must be rapidly



**Figure 1.** A force alignment system for Silicon Photonics wafers based on direct top metrology and XYZ piezoelectric stages and precision nanopositioning stages to combine the fastest alignment speeds with the highest flexibility.

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