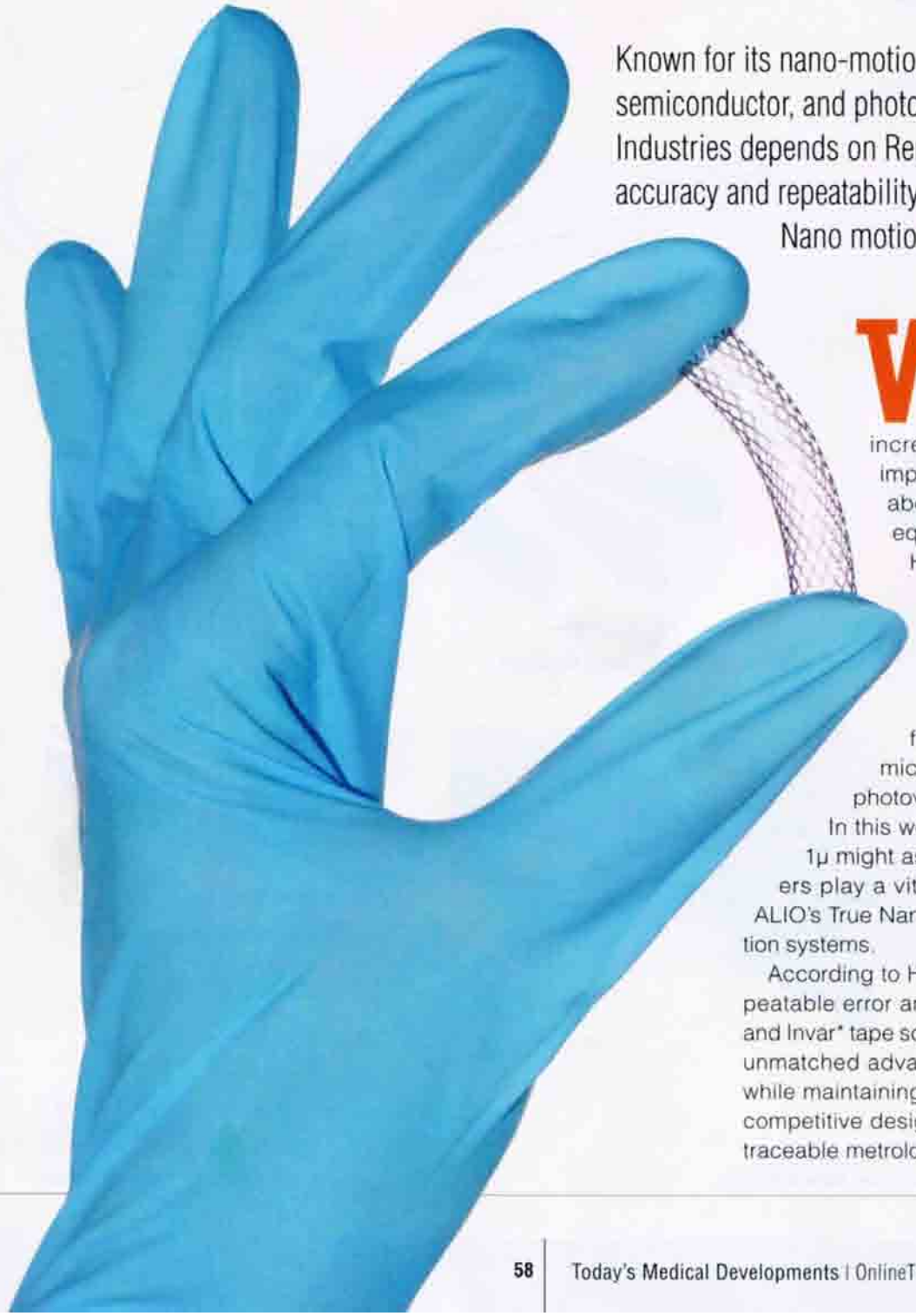
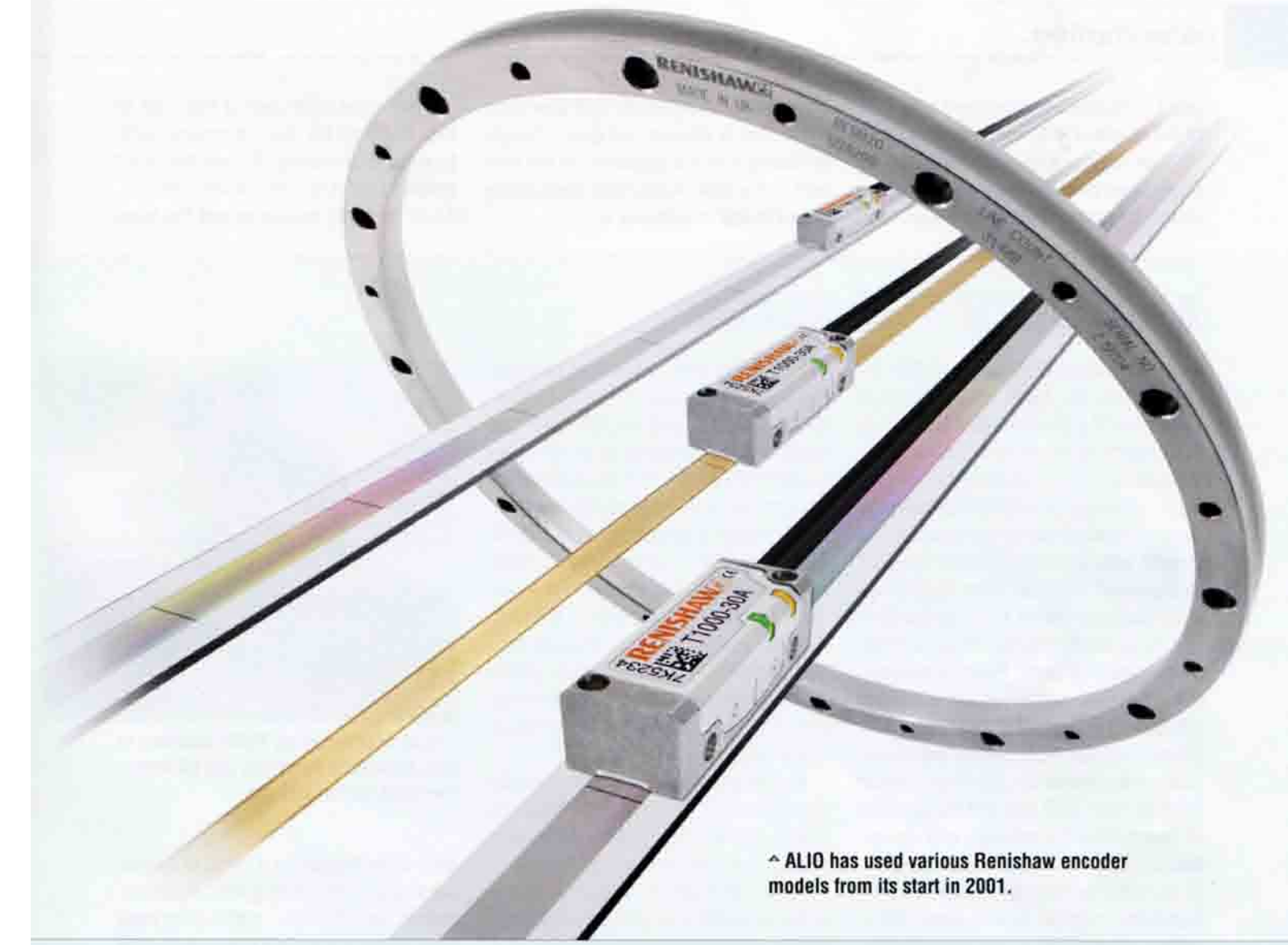
Tiny World
of Nano-Motion Systems



Known for its nano-motion stages for biomedical, semiconductor, and photovoltaic applications ALIO Industries depends on Renishaw encoders for the accuracy and repeatability needed to drive its True Nano motion system solutions.

Wheat Ridge, CO-based ALIO Industries' CEO Bill Hennessey lives in a world where small increments of motion carry large importance. In fact, he obsesses about nanometers and the inadequacy of mere planar precision. His company designs and builds some of the most precise automation stages for nano-level manufacturing and research applications, including microlithography, fiber optics, medical devices, micro-machine tools, geomatics, photovoltaics, and semiconductors. In this world, where a misalignment of 1µ might as well be 1m, the right encoders play a vital role in the performance of ALIO's True Nano and 6D Nano Precision motion systems.

According to Hennessey the minimal non-repeatable error and low cost of Renishaw steel and Invar* tape scale encoders give ALIO stages unmatched advantages in exotic applications, while maintaining a cost and footprint edge on competitive designs. ALIO also provides NIST-traceable metrology data utilizing the Renishaw



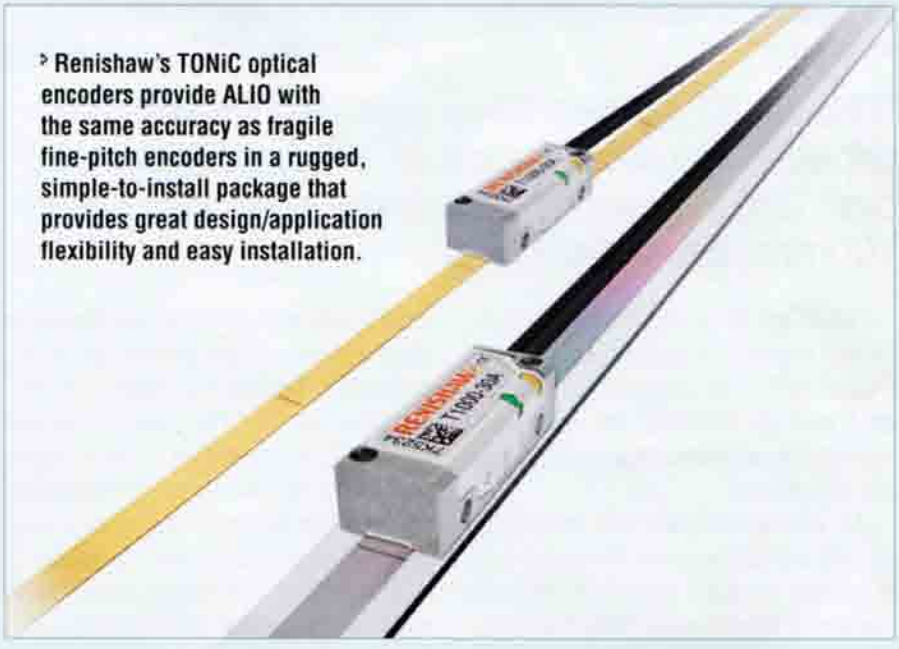
^ ALIO has used various Renishaw encoder models from its start in 2001.

ML10 laser interferometer system to verify performance.

The path to precision for ALIO motion systems starts with the thinking behind them (ALIO is Latin for a new direction).

According to Hennessey, accuracy and repeatability relate to a planar positioning solution, but do not account for straightness, roll, pitch, and yaw.

"We think in 6D terms, rather than 2D," he explains. "Accuracy typically means a position on a plane, while we are aiming for accuracy to a point in space, where straightness, roll, pitch, and yaw affect the outcome. Even many engineers do not understand that you can have excellent repeatability to a planar position while experiencing



> Renishaw's TONiC optical encoders provide ALIO with the same accuracy as fragile fine-pitch encoders in a rugged, simple-to-install package that provides great design/application flexibility and easy installation.

point-in-space misalignment because of the degrees of freedom in an axis.

"Our designs and manufacturing objectives are focused on nano precision of straightness, flatness, and elimination of roll, pitch, and yaw in an axis. This is always our goal, though in reality it is not possible to be perfect in the real world, only passionate about trying to achieve it."

This kind of thinking has led to two patents for the company, with four more pending. To get the point across that it is a 6D world, not 2D, ALIO recently trademarked the term

ALIO SETS THE STAGE

Intelligent Micro Patterning (IMP), St. Petersberg, FL, uses an ALIO 4-axis solution in its SF-100 line of maskless lithography systems to pattern micro-scale features on conventional flat surfaces, as well as provide the unique ability to produce features on non-flat and curved substrates. IMP was founded as a spin-off of Smart Filter Technology work done by David Fries at the University of South Florida. Prior to Fries' development of Smart Filter Technology, there were no commercially available processing systems for patterning non-silicon, non-flat materials on the micro-scale. Fries joined Dr. Jay Sasserath in 2001 to form IMP and put the benefits of Smart Filter Technology, and its collection of U.S. and International patents, to work for various applications in the munitions, medical, and research fields, among others. One of the unique medical applications for the system involves the placement of pharmaceutical materials on a stent.

panies using IMP's maskless lithography systems for applications in biotech, micro-fluidics, and MEMS. The IMP maskless lithography systems allow researchers to try out many different designs, quickly and cost-effectively.

"Our niche is on the research and development side," Sasserath adds. "Most important in the R&D world is the ability to turn quick iterations of different designs, and the ability to produce multiple designs on one wafer. This allows for cost-effective testing and confirmation of design configurations through empirical evidence."

Previous methods using photomasks may take three to four design attempts, at a cost of $1,000 each, and the turn-around time was days versus hours.

"With our systems, users can design in the morning and start fabrication in the afternoon," Sasserath explains.

Using ALIO stages has also provided financial advantages for IMP.

"The stages we purchase from ALIO have better performance specifications than the stages we previously used, and they are priced significantly lower," Sasserath states. "The stage is the most expensive subassembly in our system, as it is the key to our system's performance. The ability to move very precisely, at a good price point, is critical."

> 'The ALIO stages have provided us with the capability to stitch together 1µ sized features over large areas, often greater than 100mm x 100mm,' Sasserath says.

"Maskless lithography on curved substrates is unique to us," says Sasserath, CEO of IMP. "The Smart Filter Technology, with its mercury arc lamp light source, also provides cost and throughput advantages."

According to Sasserath, two-thirds of IMP customers are involved with university research programs, with the remaining third coming from R&D com-

Smart Filter Technology uses proprietary, micro-optical techniques to project master images on a range of diverse substrates – including quartz, ceramics, metals, and plastics – without the need for a photomask. IMP's line of SF-100 systems patterns individual images across the substrate, then stitches them together to make large dies or multiple copies of the same die on the same substrate. The role of the stage is critical to the stitching, as it controls the alignment of the exposures.

^ ALIO uses Renishaw TONiC encoders to help achieve its True Nano and 6D Nano Precision motion systems.

"The ALIO stages have provided us with the capability to stitch together 1µ sized features over large areas, often greater than 100mm x 100mm," Sasserath says. "The stitches are so accurate they are not observable under 400X magnification, and the reliability has been fabulous. Each stage works out of the box, and we have had no field failures reported to date."

For more information on Intelligent Micro Patterning (IMP), please visit intelligentmp.com

6D Nano Precision, helping to distinguish its unique 6D approach from the typical 2D.

"6D Nano Precision comes into play when you are thinking about more than repeatability and accuracy in the plane," Hennessey explains. "This becomes critically important when stitching features together, where you must look at things micron by micron with a camera or process. This is where 6D comes into its own, because some of these products have contours, like a lens, so if your motion system is pitching up or down, you may not be able to achieve the needed measurement data."

^ Intelligent Micro Patterning (IMP) uses ALIO stages in maskless lithography applications for the medical field, such as production of stents capable of carrying pharmaceutical materials. This photo shows an IMP-produced stent at 300X magnifications. The circles are patterns in the photo-resist where medication can be deposited in a separate process step.

Manufacturing plays an important role in ALIO product performance too. In most cases, the primary material is aluminum, but the company also uses granite, steel, stainless steel, and ceramics. The company's proprietary techniques encompass machining and metal treatments.

> **'We think in 6D** terms, rather than 2D,' Hennessey explains. 'Accuracy typically means a position on a plane, while we are aiming for accuracy to a point in space.'

"We do a lot of different things to the metal in our treatment processes, machining, and designs," Hennessey says. "When the goal is nano precision, you have to pay special attention to flatness and perpendicularity."

As a result, Hennessey says ALIO's mechanical bearing stages can equal

or exceed the precision of typical air-bearing stages and can be an order of magnitude more precise than legacy mechanical bearing designs.

"Our competitors try to overcome mechanical deficiencies with ultra-high-resolution encoders, compensation schemes, software, and controllers, while much of the secret is in the design and manufacture of our stages," Hennessey explains.

ALIO has used various Renishaw encoder models from its start in 2001.

"The encoder is a very important component in achieving True Nano and Renishaw's repeatability and accuracy from basic tape scales and Invar scales are unmatched," Hennessey adds.

'Renishaw products have consistently met or exceeded their performance claims, a practice we strive to emulate with our own,' Hennessey states.

The TONiC optical encoder is currently a mainstay with ALIO. TONiC optical encoders provide the same accuracy as fragile fine-pitch encoders, but in a rugged, simple-to-install package. The compact readhead (35mm x 13.5mm x 10mm) allows great design/application flexibility and easy installation on micro-manufacturing systems. TONiC is available in both linear and rotary versions, offering speeds to a maximum of 10m/s (3.24m/s @ 0.1µm resolution), fine resolution to 1nm, and operating temperatures up to 70°C.

TONiC delivers fine pitch caliber performance by combining innovative optics of very high signal-to-noise ratio, with dynamic signal processing to ensure ultra-low sub divisional error (SDE) and jitter. Two integral readhead LEDs give quick and easy set-up and diagnostics. TONiC reads a variety of linear and rotary scale types including a new version of Renishaw's industry standard gold, stainless steel, and Invar scales, featuring the auto-phase IN-TRAC optical reference mark. Integral dual limits are also available enabling users to select end-of-travel position.

Although ALIO stages can be interfaced to existing customer controllers, Hennessey says the highest performance is achieved with motion controllers that optimize the capability of the motion system in processing en-

coder feedback very quickly. ALIO primarily uses linear servomotors, torque motors, and voice coils plus some ceramic servomotors in their products; the decision is application dependant.

ALIO's primary products are nano-precision linear and rotary stages for stand-alone motion systems or stackable axes in various serial kinematic structures. Stages are available for enduser and OEM applications in atmospheric, cleanroom and vacuum environments. A typical 200mm stage comes as standard with less than 1µ of flatness and straightness with precision crossed roller bearings and less than ±30µm repeatability when equipped with the TONiC encoder. True Nano air bearing systems with TONiC encoders offer less than ±25µm repeatability with high stiffness and speeds from 1µ/sec to over 1m/sec to suit the application. Applications (see sidebar) include nano-metrology, FPD, ink jet deposition, solar scribe, laser machining, and others.

It is no coincidence that each product's performance is validated by a Renishaw laser interferometer, providing a NIST traceable record for the customer.

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ALIO currently has two patents for parallel kinematic systems – known as Hexapods – which have forward and inverse kinematics to assure path and velocity nano precision to a 6D point in space, as well as two more patents pending for its Nano Z and planar air bearing systems. Designed with a large open center, the standard Nano Z virtually eliminates pitch, yaw, and roll over the 24mm travel range, and uses Renishaw encoders with the Invar scale to achieve better than 100µm of accuracy when configured for optional extreme precision.

"Renishaw told us their top spec on repeatability and accuracy, so we are pushing up against this limit with better-than-expected performance," Hennessey concludes. **tmd**

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