CMM INTERNATIONAL

COMMERCIAL MICRO MANUFACTURING

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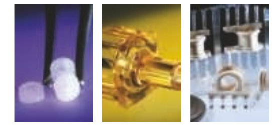

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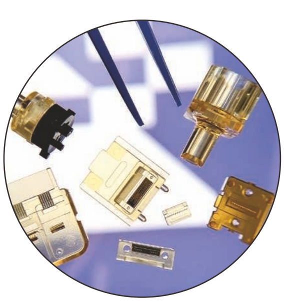

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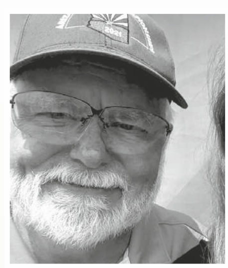

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16.1

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COMMERCIAL MICRO MANUFACTURING

ON THE COVER

The picture shows the mp6 micropump for liquids and gases from Bartels Mikrotechnik. The micropump is piezo-based, ultra-small and lightweight. It accurately transports fluids in life sciences, diagnostic, biotechnological and other applications.

Image courtesy of Bartels Mikrotechnik.

www.bartels-mikrotechnik.de/en

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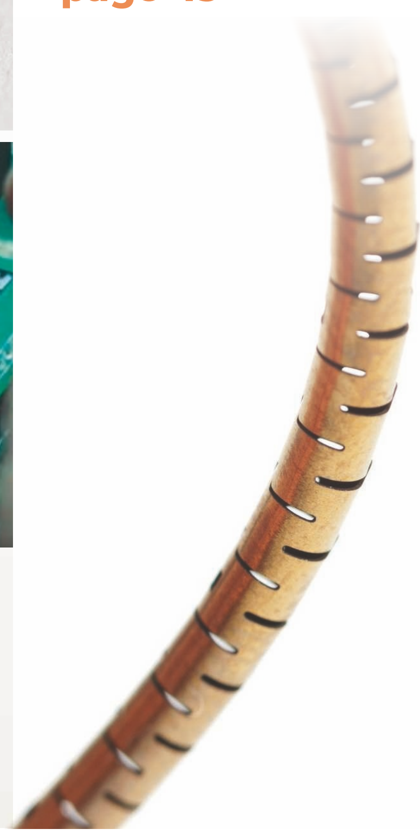


from the EDITOR

A belated 'Happy New Year' readers, and welcome to the first 2023 CMM issue. Topics covered include laser micromachining, the global electronic chip shortage and precision CNC machining, focussing particularly on the medical, electronics and dental markets. I have briefly summarised a select few of the pieces below.

A case study details how Aerotech's nanopositioning system, combined with a femtosecond laser, enables Femtika's Laser Nanofactory workstation to deliver "fast and highly precise" micromachining capabilities, these being 3D printing (multiphoton polymerisation (MPP)), laser ablation and selective laser etching (SLE). Femtika, a longstanding Aerotech customer, previously used piezo stages and found that switching to Aerotech's linear stages allowed for significantly improved quality and a factor of ten increase in manufacturing speeds of larger microstructures.
The company then managed to achieve an additional factor of 10 increase in speeds through the use of Aerotech's AGV galvo scanners.

Moving on, an article from Dogan Basic at GF Machining Solutions highlights the advantages of using ultra-short pulse (USP) lasers in the micromachining of ever smaller implantable medical devices. The miniaturisation trend is set to continue as manufacturers seek to "reduce invasiveness and increase effectiveness", and the USP laser is considered a key enabling technology. Critical factors in determining manufacturability and/or manufacture method of a new part design are, as in most industries, cost, quality and cycle time. Manufacturing issues to be considered include "defects such as heat affected zone (HAZ), burrs, machining debris and recast layer". Dogan explains how GF Microlution USP laser machines, namely the ML-5 laser micromachining and MLTC laser tube cutting systems, and more specifically femtosecond lasers, can eliminate the aforementioned.

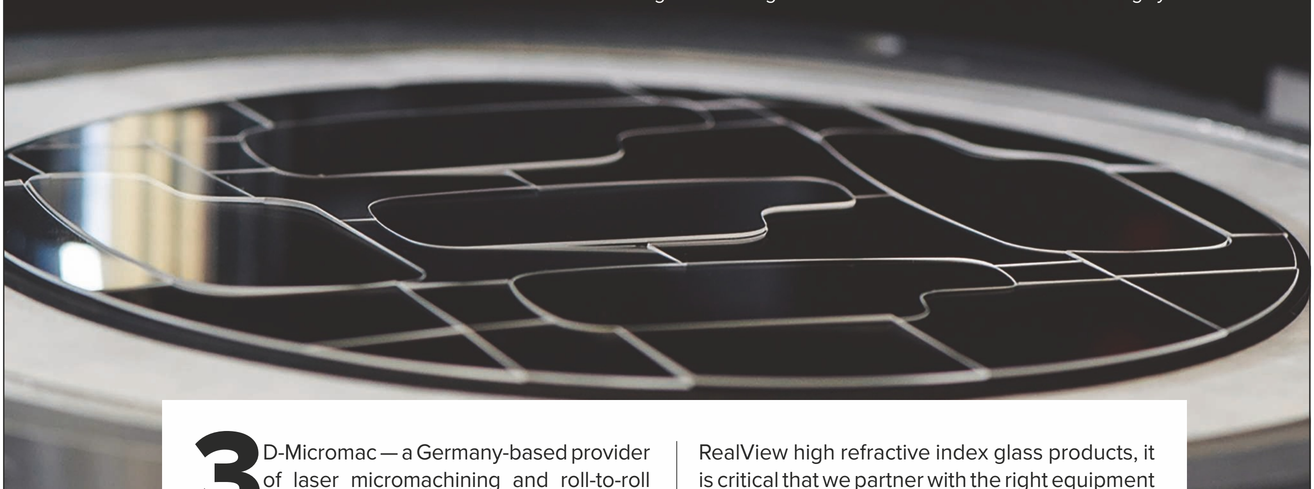
Lastly, a comment from Mike Thomas at Classic Components outlines the advantages of turning to independent distributors in counteracting the global shortage of electronic chips. Mike focuses on the impact the shortage has had on the automotive industry, made all the more significant since it underforecast new vehicle sales at the start of the pandemic. This meant that chip manufacturers prioritised supply to other markets such as consumer electronics; and car manufacturers have consequently found themselves "eliminating certain features in new vehicles because they are unable to obtain enough chips to ensure full functionality". Mike stresses the importance of having an independent distribution plan in place for situations such as this, since independent distributors can be relied upon to "get parts that work, when needed, at a competitive price."

And that sums up my contribution for this issue. As I have said many times before, topic suggestions and editorial submissions are welcomed, so please do contact me on the email below.

Elizabeth Valero, editor
elizabeth@cmmmagazine.com

3D-Micromac and SCHOTT enter development partnership to improve processing performance of SCHOTT RealView high refractive index wafers

► *Layout of SCHOTT RealView eyepieces on a high refractive index wafer following laser cutting with a 3D-Micromac laser micromachining system.* ►



3D-Micromac — a Germany-based provider of laser micromachining and roll-to-roll laser systems for the semiconductor, photovoltaic, glass and display markets—and SCHOTT, a Germany-based manufacturer of specialty glass and glass-ceramics, have entered into a joint-development partnership (JDP) to improve the processing performance of SCHOTT RealView high refractive index wafers used in manufacturing waveguides for next-generation augmented reality (AR) and mixed reality (MR) headsets.

The JDP builds on an existing multi-year relationship between the two companies, and it will focus on two key areas: the development of a dedicated laser cutting process for SCHOTT RealView glass wafers that increases glass edge strength for improved production yields; and the development of a high-volume manufacturing-capable laser micromachining tool that can achieve a throughput of nearly 600 AR eyepieces per hour, or approximately five million AR eyepieces annually in 24/7 production. While the laser micromachining process and system will be optimised for SCHOTT RealView, 3D-Micromac will ensure its compatibility with other materials and sell the system to any end customer for any glass product.

Matthias Jotz, head of product management for augmented reality at SCHOTT, commented, “High refractive index glass is a key component for achieving optimum field of view and first-class image quality for AR headsets, providing the ultimate user experience. To scale up manufacturing on our patented SCHOTT RealView high refractive index glass products, it is critical that we partner with the right equipment suppliers that can support our manufacturing goals with enabling process solutions. SCHOTT has worked with 3D-Micromac over many years, and their expertise in laser micromachining make them an ideal partner for developing a dedicated laser cutting technology for our augmented reality products.”

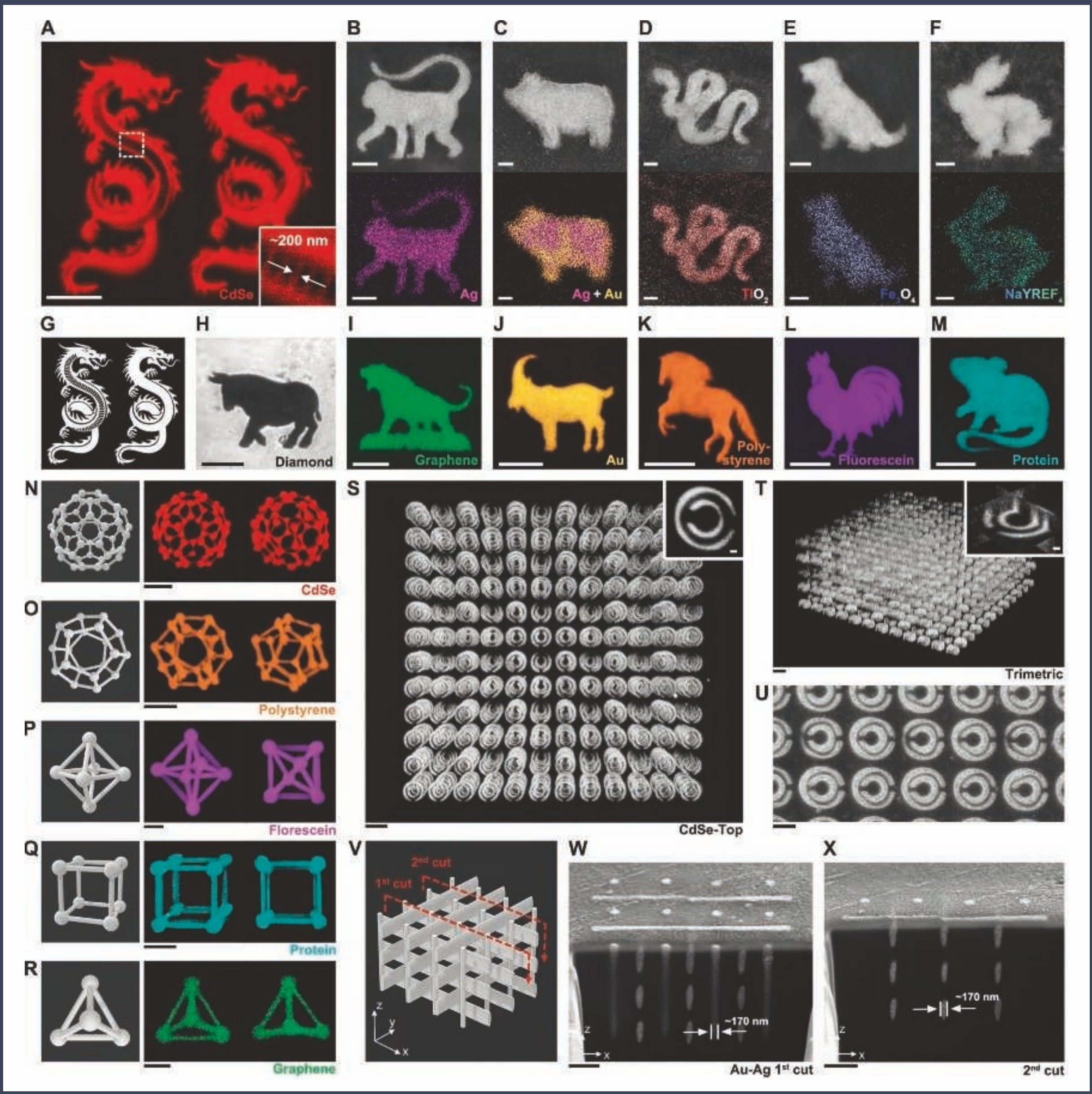
Uwe Wagner, CEO of 3D-Micromac, added, “3D-Micromac has been offering innovative laser machining solutions for the AR device market for several years, and this strategic partnership with SCHOTT, one of the foremost leaders in specialty glass, will further position us as a leading solutions provider for this high-growth-potential market. We believe that SCHOTT’s strong know-how and expertise in glass processing and material science, coupled with our leadership in laser micromachining, will enable us to develop new process solutions that can improve the bending strength of high refractive index glass to optimise yields while reducing production costs.” ■

3D-Micromac
https://3d-micromac.com

SCHOTT
www.schott.com

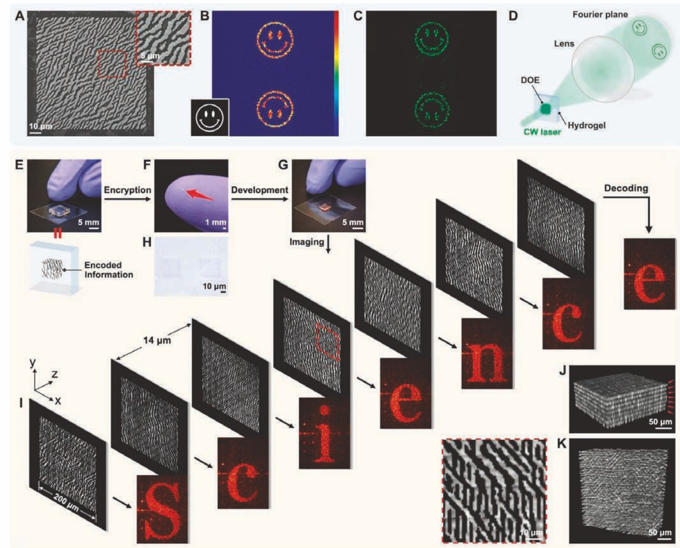
Researchers at Carnegie Mellon University and Chinese University of Hong Kong develop hydrogel shrinking method for printing smaller nanodevices

Researchers Yongxin (Leon) Zhao—at Carnegie Mellon University (CMU), US—and Shih-Chi Chen, at the Chinese University of Hong Kong (CUHK), China, have developed a hydrogel shrinking method for the printing of smaller, intricate nanodevices.



▶ *Demonstration of material variety. (A) Fluorescent image of two dragons of cadmium selenide quantum dots without shrinking; the inset shows a resolution of ~200 nm. (B-F) Scanning electron microscope (SEM) (top) and energy-dispersive X-ray spectroscopy (bottom) images of a monkey of silver; pig of gold-silver alloy; snake of titanium dioxide; dog of iron oxide; and rabbit of NaYREF⁴, respectively. (G) Designed dragon patterns in (A). (H) Optical microscopy image of an ox of diamond. (I-M) Fluorescent images of a tiger of graphene quantum dots; goat of fluorescent gold; horse of polystyrene; rooster of fluorescein; and mouse of fluorescent protein, respectively.* ▶

Image courtesy of the Chinese University of Hong Kong (CUHK).



▶ Fabrication of DOE and applications in 3D optical storage and encryption. (A) SEM image and a zoom-in view of a fabricated diffractive optical element (DOE). (B) Simulated intensity distribution at the Fourier plane of the DOE; inset: an encoded smiley. (C) Image recorded from the fabricated DOE in (A). The 0th order is spatially blocked to avoid camera damage. (D) Schematic of the optical setup to record the encoded image. (E-G) Demonstration of optical storage and encryption: (E) an expanded hydrogel patterned with designed information; (F) the gel in (E) after fully shrinking and dehydration to realise physical encryption; (G) the re-expanded gel is deposited with cadmium selenide and developed to decrypt the stored patterns. (H) Optical image showing two encrypted seven-layer hologram patterns in (F). (I) Fluorescent images of the decrypted holograms, where 'Science' is decoded; and (J, K) 3D views of the decrypted holograms. ▶

Image courtesy of CUHK.

A conversation in 2019 between Zhao, the Eberly family career development associate professor of biological sciences in CMU's Department of Biological Sciences, and Chen, a professor in the CUHK's Department of Mechanical and Automation Engineering, led to them combining their expertise to find a means of reducing the size of printable nanodevices to as small as tens of nanometres or several atoms thick.

Zhao founded the Zhao Biophotonics Lab at CMU, a research group that develops expansion microscopy (ExM) techniques for the study of biological and pathological processes in cells and tissues. The objective of these techniques is to enlarge microscopic samples embedded in a hydrogel, thus eliminating the need for a more powerful microscope to view finer details.

The hydrogel shrinking method is described as the opposite of ExM. It involves creating 2D and 3D patterns of materials in a hydrogel and shrinking them for nanoscale resolution.

Chen is known for the development of an ultrafast two-photon lithography (2PL) system. The pulse width of the system's femtosecond laser can be changed to form patterned light sheets, allowing for an entire image containing hundreds of thousands of pixels (voxels) to be printed at once, without compromising the axial resolution.

"The hydrogel shrinking method is described as the opposite of ExM. It involves creating 2D and 3D patterns of materials in a hydrogel and shrinking them for nanoscale resolution."

The manufacturing technique used for the hydrogen shrinking method is called femtosecond project two-photon lithography (FP-TPL). It is said to be up to 1,000 times faster than previous nanoprinting techniques and could lead to cost-effective, large-scale nanoprinting for use in in biotechnology, photonics or nanodevices.

The technique involves directing the femtosecond two-photon laser to modify the network structure and pore size of the hydrogel, creating boundaries for water-dispersible materials to define the required pattern. The hydrogel is then immersed in water containing nanoparticles of metal, alloys, diamond, molecular crystals, polymers or fountain pen ink, and these are attracted to and self-assemble along the laser-printed pattern in the hydrogel.

As the hydrogel dehydrates and shrinks, the nanoparticles become more densely packed and connect to each other. For example, if a printed hydrogel is placed into a sliver nanoparticle solution, the gel can shrink up to 13 times its original size, making the silver dense enough to form a nanowire capable of conducting electricity.

The research team demonstrated the method's use for encrypted optical storage (such as how CDs and DVDs are written and read with a laser) by designing and building a seven-layer 3D nanostructure that reads 'Science' after being optically decrypted.

Each layer contained a 200 x 200 pixel hologram of a letter. After shrinking, the entire structure appeared as a translucent rectangle under an optical microscope. One would need the right information on how much to expand the sample and where to shine a light through to read the information.

Based on the result, 5 petabits worth of information could be packed in a cubic centimetre of space. This equates to c. 2.5 times of all US academic research libraries combined.

The researchers' future goal is to build functional nanodevices with multiple materials.

Zhao commented: "In the end, we would like to use the new technology to fabricate functional nanodevices, like nanocircuits, nanobiosensors or even nanorobots for different applications. We are only limited by our imagination."

The results of the collaboration are published in the journal Science[1]. ■

Carnegie Mellon University
www.cmu.edu

Chinese University of Hong Kong
www.cuhk.edu.hk/english

Reference

[1]Han, F., Gu, S., Klimas, A., Zhao, N., Zhao, Y. and Chen, S. (2022). *Three-dimensional nanofabrication via ultrafast laser patterning and kinetically regulated material assembly.* Science, volume: 378, issue: 6626, pp. 1325–1331.

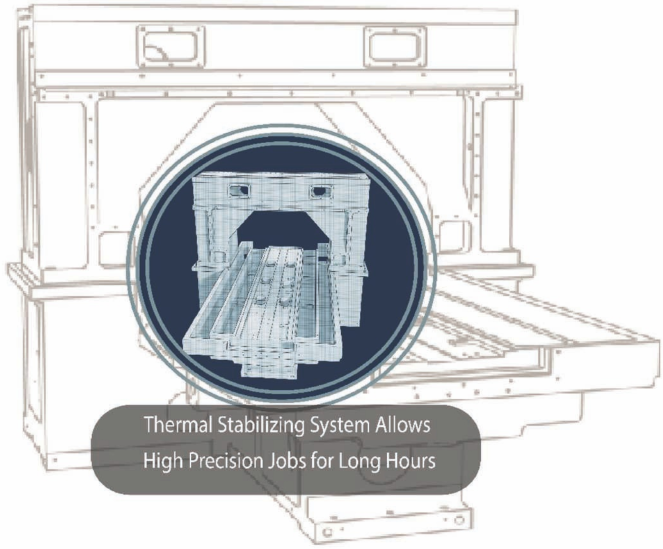
Available at: bit.ly/3Qk180g

Heidelberg announces installation of 150th MLA 150 maskless aligner

▶ *The MLA 150 maskless aligner.* ▶
Image courtesy of Heidelberg Instruments Mikrotechnik.

Germany-based Heidelberg Instruments Mikrotechnik (Heidelberg) has announced the 150th installation of its MLA 150 maskless aligner.

Introduced in 2015, the MLA 150 is an alternative to mask-based aligners, offering extremely high exposure speed, high frontside and backside alignment accuracies, warpage compensation, high resolution, high accuracy and the ability to expose on any substrate size from a few millimetres up to eight inches square. Furthermore, the maskless aligner's non-contact exposure technique and ease of use makes it an ideal tool for rapid prototyping, mid- to low-volume production and research and development. Common application areas include electronics, microelectromechanical systems (MEMS), microfluidics, microoptics, sensors and many others.



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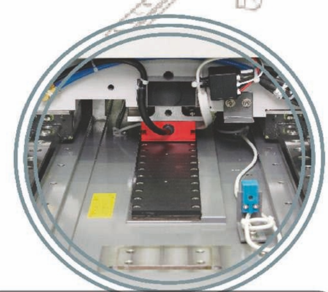
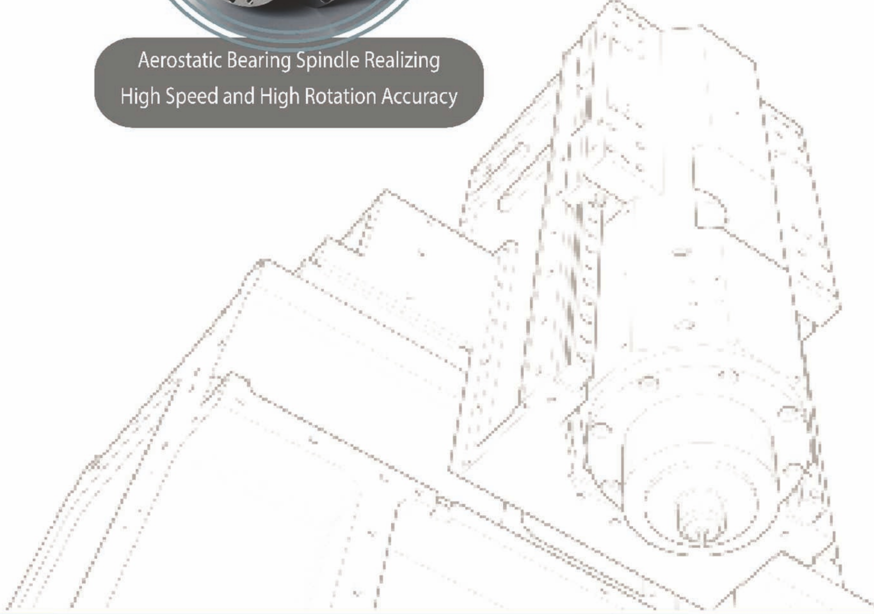


High Precision Positioning by
Linear Motor Control Technology



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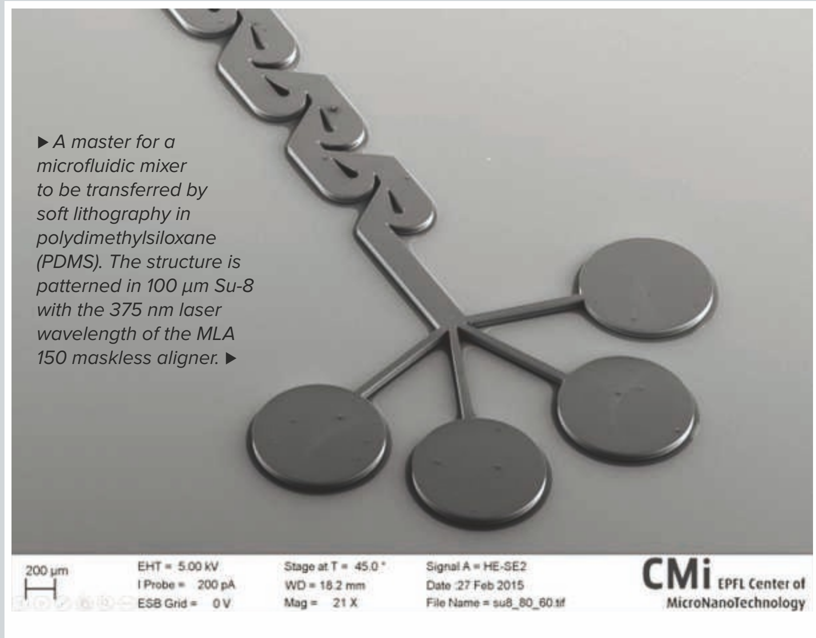
The beta-version of the MLA 150 was installed at the Center of MicroNanoTechnology (CMi) of the École Polytechnique Fédérale de Lausanne (EPFL) Lausanne, Switzerland, in August 2014. The CMi is a complex of clean rooms and processing equipment devoted to making microtechnology accessible to trained academic and industrial users. It is also one of the pioneers in maskless lithography.

The CMi installed a second MLA 150 in 2022. Commenting on this, Julien Dorsaz, the manager of the photolithography division of the CMi, said: “The MLA 150 is today one of the most important equipment in our facility, and there are many users that daily use the machine for printing. So, we wanted to have two of them.”

A 30-minute interview with Dorsaz on the CMi’s experience of the MLA 150 is available at: https://bit.ly/3WV8tWw. ■

Heidelberg Instruments Mikrotechnik
www.heidelberg-instruments.com

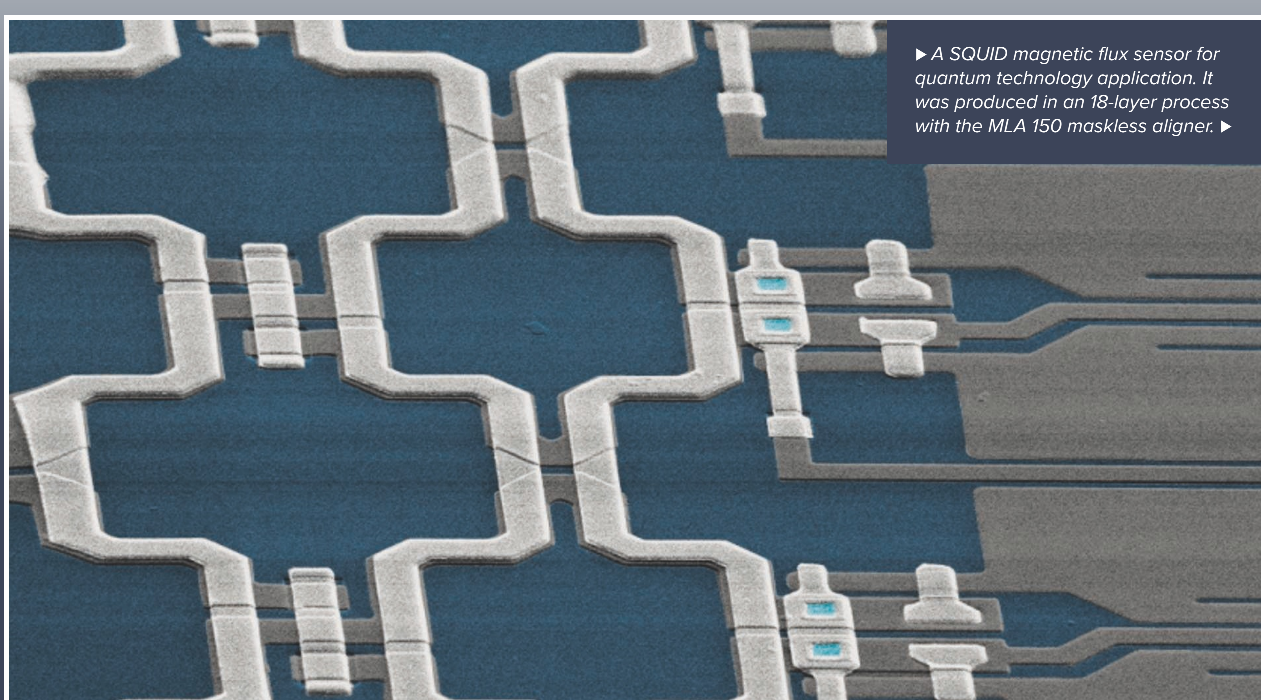


▶ *A master for a microfluidic mixer to be transferred by soft lithography in polydimethylsiloxane (PDMS). The structure is patterned in 100 µm Su-8 with the 375 nm laser wavelength of the MLA 150 maskless aligner.* ▶

Image courtesy of the Center of MicroNanoTechnology (CMi) of the École Polytechnique Fédérale de Lausanne (EPFL).

"The MLA 150 is today one of the most important equipment in our facility, and there are many users that daily use the machine for printing."

Julien Dorsaz, manager of the photolithography division of the CMi



▶ *A SQUID magnetic flux sensor for quantum technology application. It was produced in an 18-layer process with the MLA 150 maskless aligner.* ▶

Courtesy of the Kirchhoff Institute for Physics (KIP).

Femtika uses nanopositioning systems from Aerotech in Laser Nanofactory workstation to ensure high-precision 3D micromachining of custom components

Femtika is a spinoff company of the Laser Research Centre of Vilnius University in Lithuania. The experts there have many years of experience in the research and development of high-precision 3D laser micromachining, and they specialise in hybrid micromachining technologies. This has led to the realisation of Femtika's Laser Nanofactory workstation, a universal tool that incorporates multiphoton polymerisation (MPP), laser ablation and selective laser etching (SLE) technologies. At the heart of every workstation is a femtosecond laser combined with a nanopositioning system from US-based Aerotech, enabling fast and highly precise manufacturing across the entire workspace.

Femtika has been using Aerotech's linear stages and galvo scanners since it was founded in 2013. However, the University of Vilnius has been using Aerotech equipment since 2005. There, it was used extensively by Femtika's founders for research projects and other academic work.

Reflecting on the company's early days, Dr Vytautas Purlys, CTO at Femtika, said, "Before we were introduced to the Aerotech positioning stages, we assumed that nanometre precision could only be achieved with piezo stages."

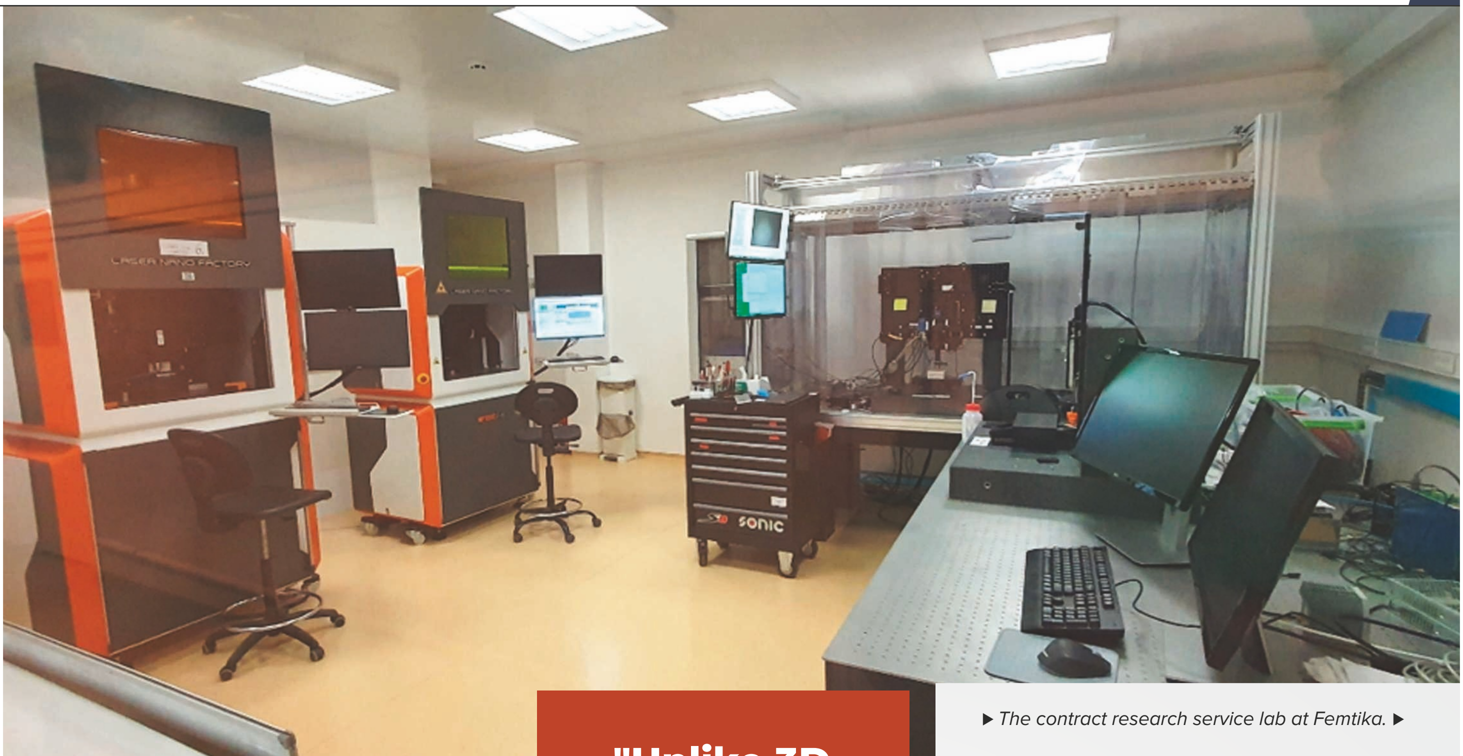
The most common solution at the time was to mount the piezo stage on a larger, less precise mechanical stage. "This approach was sufficient for small structures, but for larger structures we always had problems with stitching and extremely long manufacturing times," continued Purlys. "We then tried Aerotech's high-precision linear stages, which immediately improved the quality for larger microstructures and also allowed them to be manufactured faster, by at least a factor of 10."

▶ *Femtika's Laser Nanofactory workstation, incorporating multiphoton polymerisation (MPP), laser ablation and selective laser etching (SLE) technologies.* ▶

Soon after, it became clear that the speed could be increased by a further factor of 10 if they incorporated Aerotech's AGV galvo scanners. "I remember one project where we produced thousands of high-quality structures overnight, while our older piezo system only managed ten in the same time," Purlys enthused.

Multiphoton polymerisation

MPP is one of the highest resolution 3D printing technologies. It is based on photopolymerisation reactions that are triggered only in a focal volume of the sharply focused femtosecond laser focal point. The microstructures are printed by scanning the laser beam over the volume of the photopolymer.



▸ *The contract research service lab at Femtika.* ▸

> **"Unlike 3D printing, this is a subtractive process where the laser is used to modify the intermolecular glass structure. The laser-modified glass areas are then chemically etched away, leaving only unmodified areas."**
>
> **Dr. Vytautas Purlys, CTO at Femtika**

"A key advantage of this process is the ability to print very high resolution of structure sizes down to 150 nm," explained Purlys. "In addition, there is an exceptionally high surface quality and the ability to create 3D microobjects of any shape without the need for supports."

Examples of applications for MPP are microoptical and photonic elements, which are not only printed on planar surfaces but also directly on fibre tips, photodiodes, semiconductor integrated circuits (ICs), etc. The process is also frequently used for biomedical applications such as the fabrication of 3D scaffolds, which are support structures for cell growth that can be used for drug testing.

One machine for a variety of high-precision processes

Femtika's Laser Nanofactory workstations are not just very high resolution 3D printers. They offer many other microfabrication techniques made possible by femtosecond lasers. "Our workstations are often used for selective laser etching of glass, for example," said Purlys. "Unlike 3D printing, this is a subtractive process where the laser is used to modify the intermolecular glass structure. The laser-modified glass areas are then chemically etched away, leaving only unmodified areas." This is not only applied in medical technology (in microfluidic devices or micromechanical particles, for example) but also in microrobotics and the watch industry.

"In general, lasers are unique tools because of their ability to modify the volume of transparent materials without touching their surface," added Purlys. By modifying the volume of materials, different waveguides, diffractive optical elements or Bragg gratings can be realised. Surfaces can also be modified with femtosecond lasers. For example, microablation is used when tiny grooves or holes are needed on the surfaces, while surface structuring enables the production of hydrophilic or hydrophobic surfaces.

Building small features over a large area

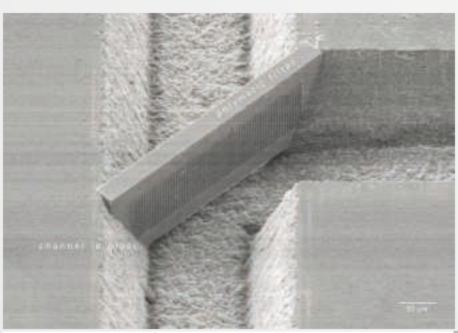
Each laser process places its own unique demands on the positioning system. Some processes require precision and resolution, others speed, still others a working range, and all this together results in quite a demanding list of requirements. "Since all of our processes are based on functional material changes, the specifications of the positioning system directly contribute to the quality of the manufactured structures," said Purlys.

Stitching together small areas to create a larger part is one of the most essential practices in the world of submicrometre printing. This is necessitated due to not only inaccuracies of the positioning system but also the material's behaviour. The

"Stitching together small areas to create a larger part is one of the most essential practices in the world of submicrometre printing. This is necessitated due to not only inaccuracies of the positioning system but also the material's behaviour. "

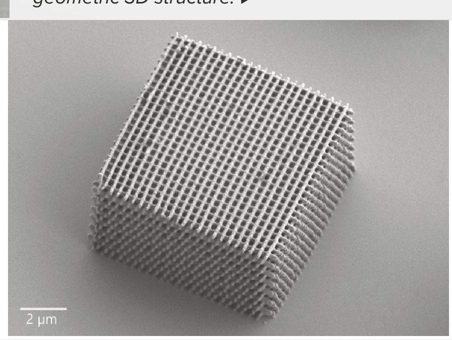
Femtika CTO illustrated the problem, "Imagine you are on the beach. While you are lying comfortably in the sand, you try to draw a circle with your finger. Between the place where you started the circle and the place where you finished it, you will notice a defect—a small pile of sand. No matter how steady and precise your hand is, the pile will be there. Now you try to draw a larger pattern with small, gridded squares, imitating the effect of the galvo scanner. You will find that your artwork is full of such heaps or stitches between the squares."

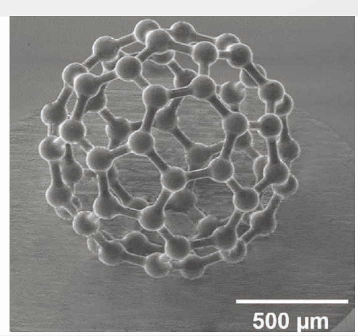
Similar problems occur in microfabrication, caused by the way the materials react to the laser pulses. Often, the galvo scanners are used to raster the laser spot over small square areas, which are then joined by repositioning them in steps, leading



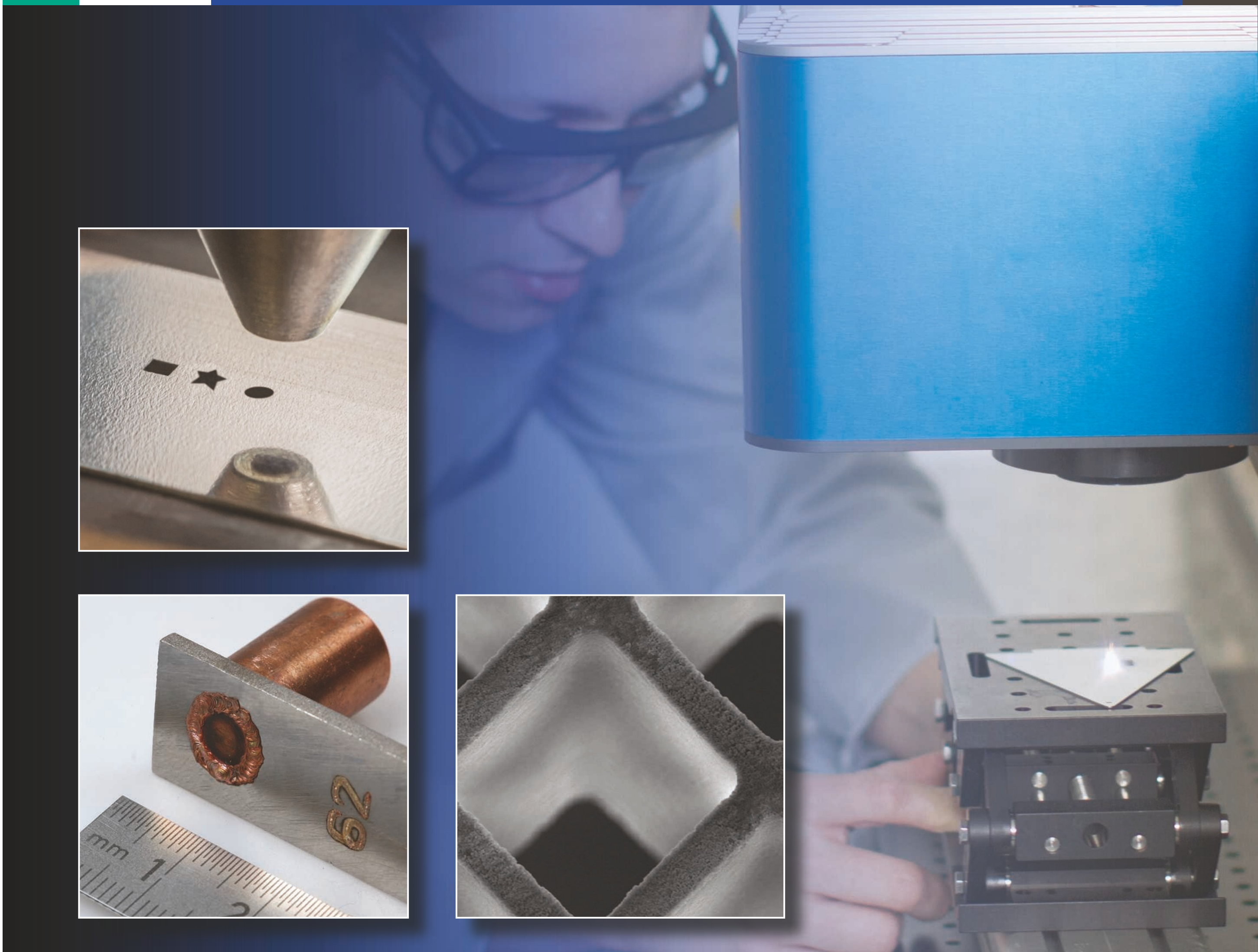
▸ Hybrid fabrication enables the rapid fabrication of channels from fused silica by laser ablation as well as integration of fine-mesh 3D filters with arbitrary geometry into those channels by MPP. To prove the effectiveness of this approach, a prototype microfluidic macromolecule separator for the development and production of next generation drugs was produced. ▸

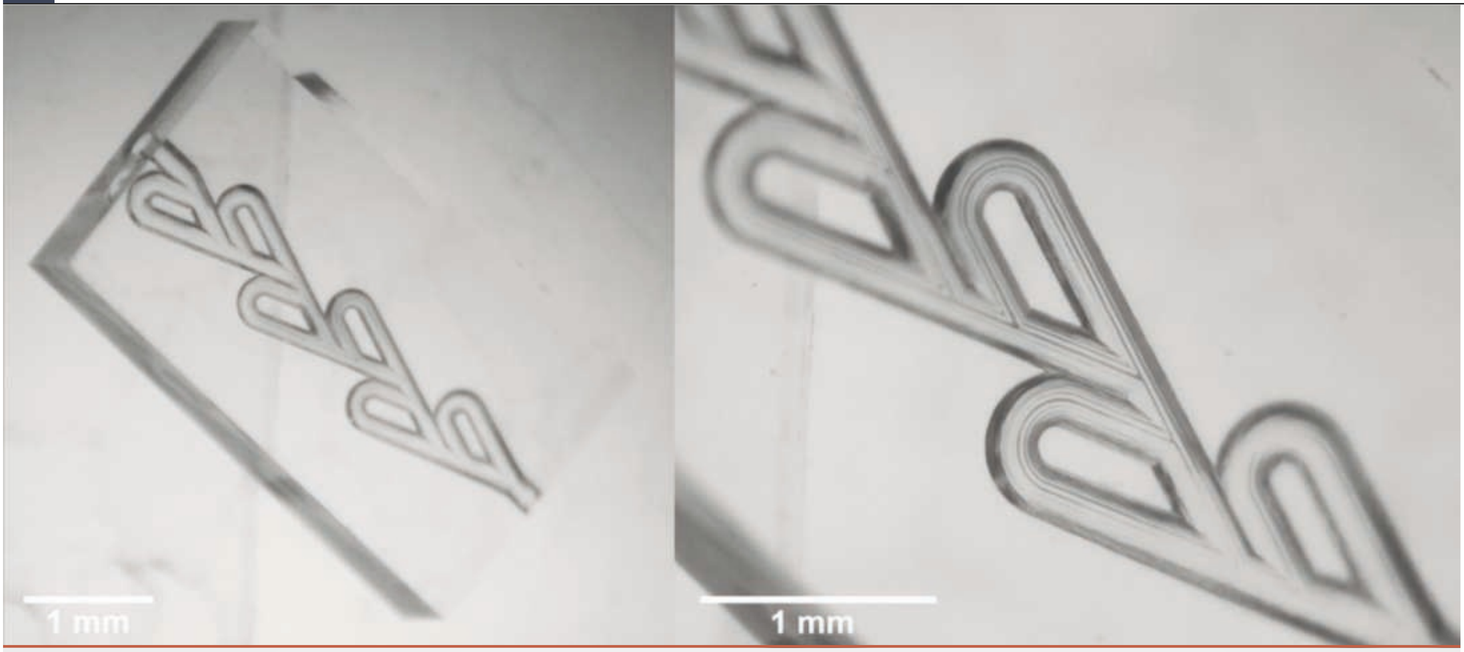
▸ *Photonic crystals produced using the MPP technique, which is suitable for almost any geometric 3D structure.* ▸





▸ *A quartz glass model of a fullerene molecule produced using SLE.* ▸





▶ *Microfluidics is one of the most popular SLE applications. Surfaces fabricated with SLE can have relatively low surface roughness (app. 200 nm root mean square (RMS)). Furthermore, SLE far surpasses ablation in terms of flexibility and enables the fabrication of 3D freeform structures, such as channels with integrated functional elements or 3D channel systems embedded in the glass volume.)* ▶

"To minimise the number of stitching errors, we actively use infinite field of view technology, where the movement is automatically divided into a fast and a slow movement and executed simultaneously with Aerotech's galvo scanners and linear tables, respectively."

Dr. Vytautas Purlys, CTO at Femtika

to errors in the joining process. This approach can significantly affect the quality of the manufactured structures. For example, microlenses manufactured in this way show considerable scattering, microparts can contain fractures and parts for the watch industry lose their aesthetic appeal.

"To minimise the number of stitching errors, we actively use infinite field of view technology, where the movement is automatically divided into a fast and a slow movement and executed simultaneously with Aerotech's galvo scanners and linear tables, respectively," explained Purlys. "In this way, the stitching is almost eliminated and the structures produced become more uniform."

Control is the key

The Laser Nanofactory workstation's overall precision is thereby limited by the least precise component, so the performance of the stages and galvos must be precisely matched. However, this is not the only important factor. The control system is an often overlooked component that performs a very important, almost invisible task.

With direct laser writing techniques, the structures are written while the table/galvo scanner is moving. When the positioning system is accelerating or decelerating, the number of laser pulses hitting the material increases. This can lead to various errors or even material damage in these areas. These problems can be solved by firing the laser pulses at constant distances from each other. If both galvo scanners and mechanical tables are used, this poses a challenge for the control system as the positions of both devices have to be taken into account.

"As longtime users of Aerotech's A3200 controller, we were excited to be able to test the new Automation1 control platform as well," said Purlys. "Apart from the significant improvements to the user interface,

"During the software migration, Femtika's experts noticed some functions that previously required 50 lines of code could now be implemented in just a few lines."

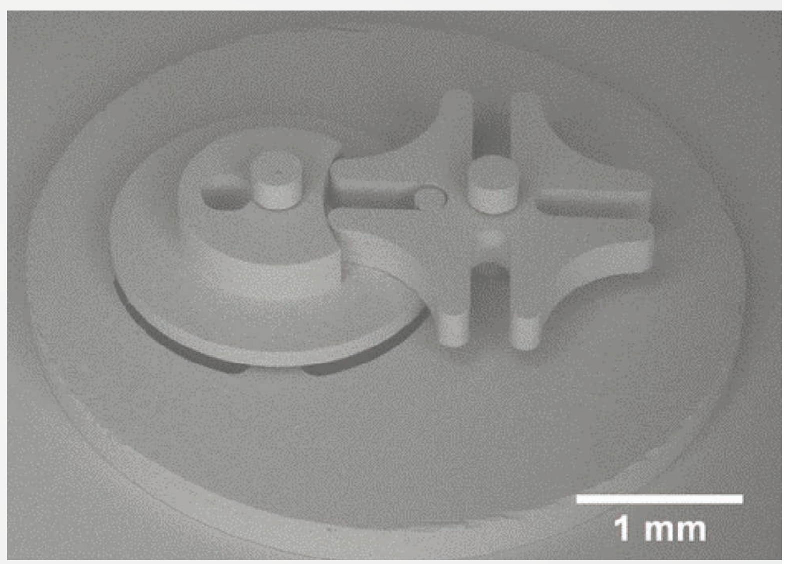
we also discovered many new useful features. For example, the way the movement is defined is now much more user-friendly, the control parameters are easier to find and their meaning is now also easier to understand. From the integrator's point of view, we like the new control API (application programming interface), which makes the implementation of various control functions much easier."

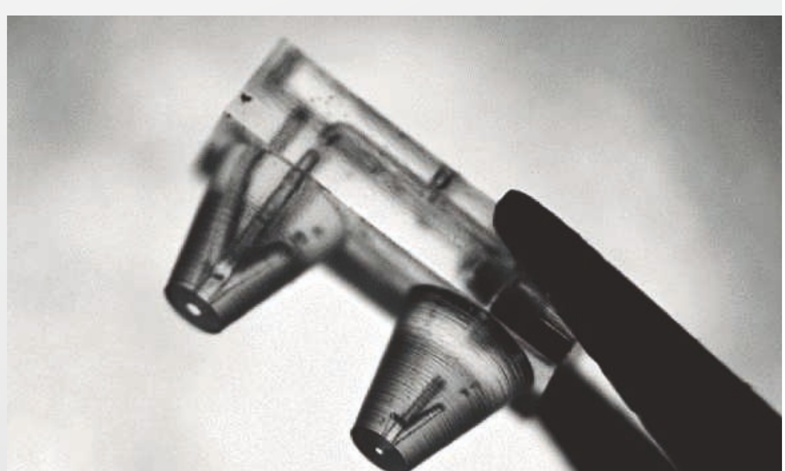
Furthermore, during the software migration, Femtika's experts noticed some functions that previously required 50 lines of code could now be implemented in just a few lines. "This and many other small improvements help us save implementation time and increase the overall quality of our products," concluded Purlys. ■

Femtika
www.femtika.com

Aerotech
https://uk.aerotech.com

▶ *The Geneva gear mechanism is one of the most commonly used devices for generating intermittent rotary motion. It comprises two interlocking elements. Turning one gear one full rotation moves the other gear by fixed 90 ° increments. With SLE, such mechanisms can be made from a single piece of glass, without the need for an assembly step.* ▶





▶ *Glass micronozzles produced using SLE.* ▶

Use of ultra-short pulsed lasers in medical device manufacturing

DOGAN BASIC, PRODUCT MARKETING MANAGER, GF MACHINING SOLUTIONS

▶ *The ML-5 laser micromachining platform from GF Microlution.* ▶

There have been great advances in medical devices over the last two centuries; Alexander Wood invented the first hypodermic needle in 1853, Rune Elmqvist invented the first implantable cardiac pacemaker in 1958 and Dr Melvin Scheinman performed the first catheter ablation on a human in 1981, all impossible without micromanufacturing processes.

Implantable medical devices have a strong trend towards miniaturisation to reduce invasiveness and increase effectiveness. This requires the manufacturers to constantly expand their capabilities, be it through advances in process engineering, purchase of newer capital or changeover to new technologies. One of the technologies that OEMs and job shops have been utilising to keep up with new medical device designs is ultra-short pulsed (USP) lasers, or lasers with pulse widths ranging from tens of femtoseconds to hundreds of picoseconds.

Challenges

There are numerous challenges faced by medical device manufacturers. Devices implanted into the human body, whether temporarily or permanently, receive a high level of scrutiny to ensure the best patient prognosis possible. Two big questions are asked before a new design is to be manufactured: "What will the cost per part be?" and "Will the part be produced at the required quality?"

▶ *The MLTC laser tube cutting platform from GF Microlution.* ▶

Understanding the cost per part before production starts is critical for each manufacturer. Contributors to the cost per part are the costs of equipment, maintenance and consumables such as electrodes or grinding wheels. The cycle time per part is another critical constituent.

The topic of whether or not a new part design can be produced at the required quality is not at all trivial. The trend of miniaturisation pushes manufacturers to either expand the capabilities of their current process or invest in new equipment to achieve the required results. For micromachining of medical parts, the manufacturing difficulties include defects such as heat affected zone (HAZ), burrs, machining debris and recast layer, as well as accurate and repeatable positioning.

Fortunately for parts manufacturers, providers of manufacturing equipment have evolved to work closely with their customers and take many of the risks out of purchasing capital through providing turnkey solutions that address both the productivity and process sides of the equation.

Solutions

Many solutions have been developed over the years to address the manufacturing need for smaller and higher quality medical devices. The change in tooling required to accommodate this trend of miniaturisation is exemplified at GF Microlution, which started as a mechanical micromachining solutions provider and evolved into an USP laser micromachining solutions provider. GF Microlution's USP laser machines incorporate femtosecond lasers, solid granite bases, high-precision motion platforms, built-in vision systems, automation and high-end optics.

"Fortunately for parts manufacturers, providers of manufacturing equipment have evolved to work closely with their customers and take many of the risks out of purchasing capital through providing turnkey solutions that address both the productivity and process sides of the equation."

Large-series production

In the case of producing parts in large series, particularly in the medical industry, beyond the notion of cost is the notion of repeatability, which is critical. It is therefore important to design equipment that ensures very high stability of quality across production batches. GF Microlution prioritised this in its development of the ML-5 laser micromachining platform and MLTC laser tube cutting platform. A feature of these platforms that is conducive to the aforementioned is a solid granite base, which allows for high acceleration without detriment to quality. Another important feature of the ML-5 and MLTC systems as regards large series production is the use of linear axes.

Then there are optional features for the avoidance of part damage and loss, such as the MLTC's sealed cut box for capturing and draining water, an important part of the closed-loop wet cutting system, which creates minimal mist and keeps the rest of the machine dry, an especially important factor in the manufacture of very small tubes.

> **"The beam delivery utilised in laser machines is important for both productivity and quality. The MLTC laser tube cutting platform is 4 axis and uses an adjustable beam expander through a fixed optics delivery system to allow for controlling of the laser kerf and divergence."**

▶ All of GF Microlution's machines have a solid granite base like the one shown. They afford exceptional thermal stability and contribute to ensuring very high stability of quality across production batches. ▶

▶ *The spindle on the MLTC platform, which is designed for very small, delicate tubing.* ▶

Femtosecond lasers

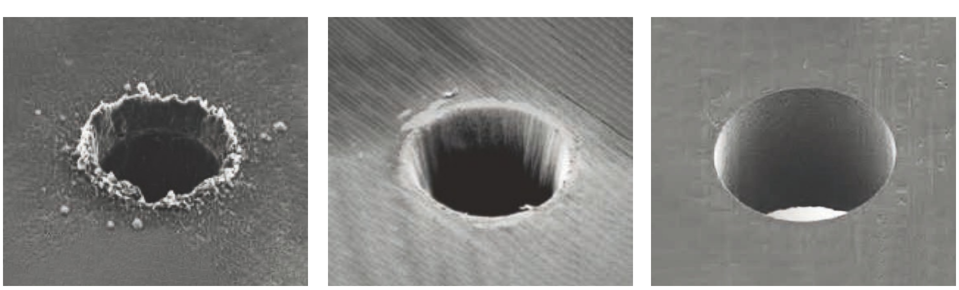
Medical parts require tight process control to ensure the safety of patients. Often, this requires complex post processing of parts to remove burrs, machining debris and recast layer. Even with precautions in place to prevent defects, the scrap rates are often high. Because of this, many producers of these parts have implemented 100 percent inspection. Using USP lasers greatly increases the quality of the features and therefore removes many of the downstream processes that add significant costs for manufacturers.

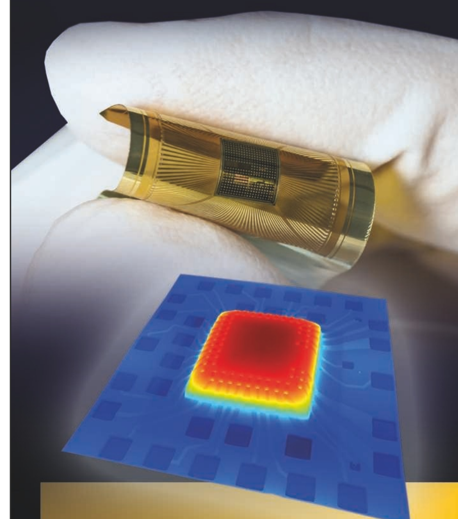
The beam delivery utilised in laser machines is important for both productivity and quality. The MLTC laser tube cutting platform is 4 axis and uses an adjustable beam expander through a fixed optics delivery system to allow for controlling of the laser kerf and divergence.

The ML-5 laser micromachining platform is 3 or 5 axis and is often used to machine thicker materials that require taper control. Manufacturers can use the 5-axis scanning unit to leverage advanced micromachining capabilities that can produce negative tapered holes and slots, drill arbitrarily shaped through-holes and contour with exceptionally small inside radii. Moreover, shops can easily achieve near-perfect machining quality, even for complex geometric features that were all but impossible to cut only a few years ago.

Both the MLTC and ML-5 platforms are optimised for their respective use cases to give process engineers the flexibility they need to achieve their quality of parts and reduce cycle times.

▶ *A comparison of nanosecond, picosecond and femtosecond performance.* ▶





MARKER BANDS	
TECHNOLOGIES	MLTC with 4-axis motion platform • Femtosecond laser • Two measurement cameras (coaxial and on-end) for in-process measurements and defect detection • Bar feeder for full automation
MATERIALS	Radiopaque precious metals (mostly platinum iridium (PtIr))
MACHINING TIME	~2 seconds
HOLE DIAMETER	~±10 µm (general customer request) ~±5 µm (capability)

▶ *Marker bands produced on the MLTC platform. These are attached to a catheter shaft via swaging or embedding to provide a high level of visibility under fluoroscopy. During surgery, the marker band serves as a shiny indicator of the exact location of the catheter tip inside the body. The MLTC small tube handling system is for 0.25 to 0.76 mm OD marker bands and the MLTC standard tube handling system is for larger than 0.76 mm OD marker bands.* ▶

Built-in vision systems

Visual checks have been a mainstay in verifying that the machined medical parts pass the required standards. Not only is the cost of visual inspection expensive but it is also prone to human error, which is especially exacerbated in small medical parts. Vision systems have become an essential tool for offloading some of the inspection workload and therefore reducing overall costs. Both the MLTC and the ML-5 have built-in vision systems to set up the parts and machine as well as to provide an additional layer of inspection.

The MLTC has a programmable camera through the optics and an end-on camera trained on the end of the tube to be machined. The cameras provide the process engineer with quick feedback on the machine and stock positions through the changeover process (whether the laser is on the centreline of the stock, for example). They also allow the process engineer to check the outer and inner diameters of tubing before each part is machined to ensure that the correct stock is loaded and that there is no damage to the material.

The ML-5 also comes with a fully integrated vision system. A common use case on this platform is for initial part setup relative to the fixture or other features on the incoming part. The machine is programmed to identify certain features and compensate locations to ensure that errors in part loading or sizing does not affect the machined features' locations.

Automation

The cost per part is greatly reduced with the use of automation throughout a part's manufacturing and verification processes. Loading/unloading parts, cleaning processes, verifying flow rate and measuring features are examples of commonly automated processes that bookend an operation. Equipment providers have become adept at working with manufacturers on providing either flexible interfaces for connecting to automation or automated solutions directly with the equipment.

One of the most commonly automated processes is bar feeding. Bar feeders allow lights out production by drastically increasing the amount of time between operator interventions for loading new material. However, in the past, these bar feeders were unable to handle small diameter tubing, which is often required by medical device manufacturers.

In 2021, GF Microlution developed its first bar feeder for tubing diameters as small as 254 µm.
Tubes of this diameter are often about as flexible as cooked spaghetti. Small diameter tubing automation has allowed manufacturers of small parts to more quickly realise their return on investment (ROI) through lights out production and reduced workload per operator per machine.

Conclusion

Over the last two decades, USP lasers have diversified from the optical R&D benches and matured into an integral tool for the medical and other industries requiring micromanufacturing capabilities. These advances in manufacturing equipment help reduce cost per part (and ultimately cost per medical intervention) as well as give design engineers more flexibility to create the next generation of medical components. ■

GF Machining Solutions
www.gfms.com

CATHETER GUIDEWIRES	
TECHNOLOGIES	MLTC with 4-axis motion platform • Femtosecond laser • Vision system for part OD/ID verification • Bar feeder
MATERIALS	Precious metals, nitinol
MACHINING TIME	~1-10 minutes per part (depending on complexity and length)
HOLE DIAMETER	±10 µm requested ±5 µm held

▶ *Catheter guidewires produced on the MLTC platform. These are used to guide a catheter into place. They have specific features and geometries to offer sufficient rigidity for reaching their destination and flexibility for contouring along the required path.* ▶

▶ *Ablation catheter tips produced on the ML-5 platform. These are used to correct heart arrhythmias.* ▶

ABLATION CATHETER TIPS	
TECHNOLOGIES	ML-5 with 5-axis motion platform (±1 µm repeatability) • Femtosecond laser • On-end vision system (2 µm repeatability to compensate part runout) • 3-axis touch probe (X, Y, Z repeatability < 2 µm)
MATERIALS	Precious metals
MACHINING TIME	~1 seconds per feature ~1 minute per part (for part measurement and drilling 35 features)
HOLE DIAMETER	~80 µm

Look to independent distributors to help solve the electronic chip shortage

MIKE THOMAS, VICE PRESIDENT AND GENERAL MANAGER, CLASSIC COMPONENTS

Supply chain shortages have become a global issue in recent years, adding a stubborn wrinkle to the fabric that keeps the economy humming. One shortage that has plagued the automotive industry since 2018 is the shortage of electronic chips. In automotives, chips control many of the features of a car, from heated seating to Wi-Fi hotspots, and without them, manufacturing cannot continue at the level consumers expect.

Supply chain disruptions are nothing new; they have become something electronic parts distributors have come to expect. With low-cost components in chronic shortage and extended lead times for delivery, manufacturers are considering the use of independent distributors to get parts on-time at the lowest possible cost without assuming additional risk.

For many companies, sourcing parts from the independent channel requires a significant shift in mindset. Some companies make the decision to place orders with independent distributors such as ourselves the very first day they are in operation because they understand the market and how we operate in it. But there is an equal number of companies that are hesitant because the chipmakers and franchise distributors have invested millions over the years to de-incentivise their customers from going to the open channel.

> **"The accelerated demand for chips in the automotive sector is going to remain steady for some time due to the current backlog. This means the long-term prognosis for those manufacturing chips for automotives is positive."**

Classic Components has been in business for over 40 years and remains one of the only premier independent distributors that is family-owned. Our maturity and resources allow us to deliver high-quality products with shorter lead times than many competitors. In fact, we can usually deliver parts in two to three weeks that the OEM or authorised distributors may not have access to for 52 weeks or longer.

Keeping automotive manufacturing running

At the beginning of the pandemic, automotive suppliers estimated a decline in consumer interest in purchasing a new vehicle and adjusted their projections accordingly. Chip manufacturers then followed suit, prioritising other sectors such as consumer electronics as they anticipated a reduced automotive manufacturing capacity. However, demand for new vehicles exceeded expectations, leaving the industry with a demand it could not fill.

The accelerated demand for chips in the automotive sector is going to remain steady for some time due to the current backlog. This means the long-term prognosis for those manufacturing chips for automotives is positive. And while things are beginning to slowly return to normal, at present, the price of hard-to-get components like chips has skyrocketed.

The shortage has led to major car manufacturers eliminating certain features in newly made vehicles because they are unable to obtain enough chips to ensure full functionality. This is where having an independent distribution plan comes into play.

If you are a manufacturer, you need to have an independent distribution plan as part of your supply chain strategy. You may not want to give a broker business and take it away from the franchise/authorised distributors, but right now, independent distributors can be strategic and can get parts that work, when needed, at a competitive price.

Classic Components' sourcing expertise includes knowing where to find alternate sources of component parts through surplus inventory, strategic relationships with other franchise/authorised distributors and taking advantage of local and overseas markets.

Investigating sources

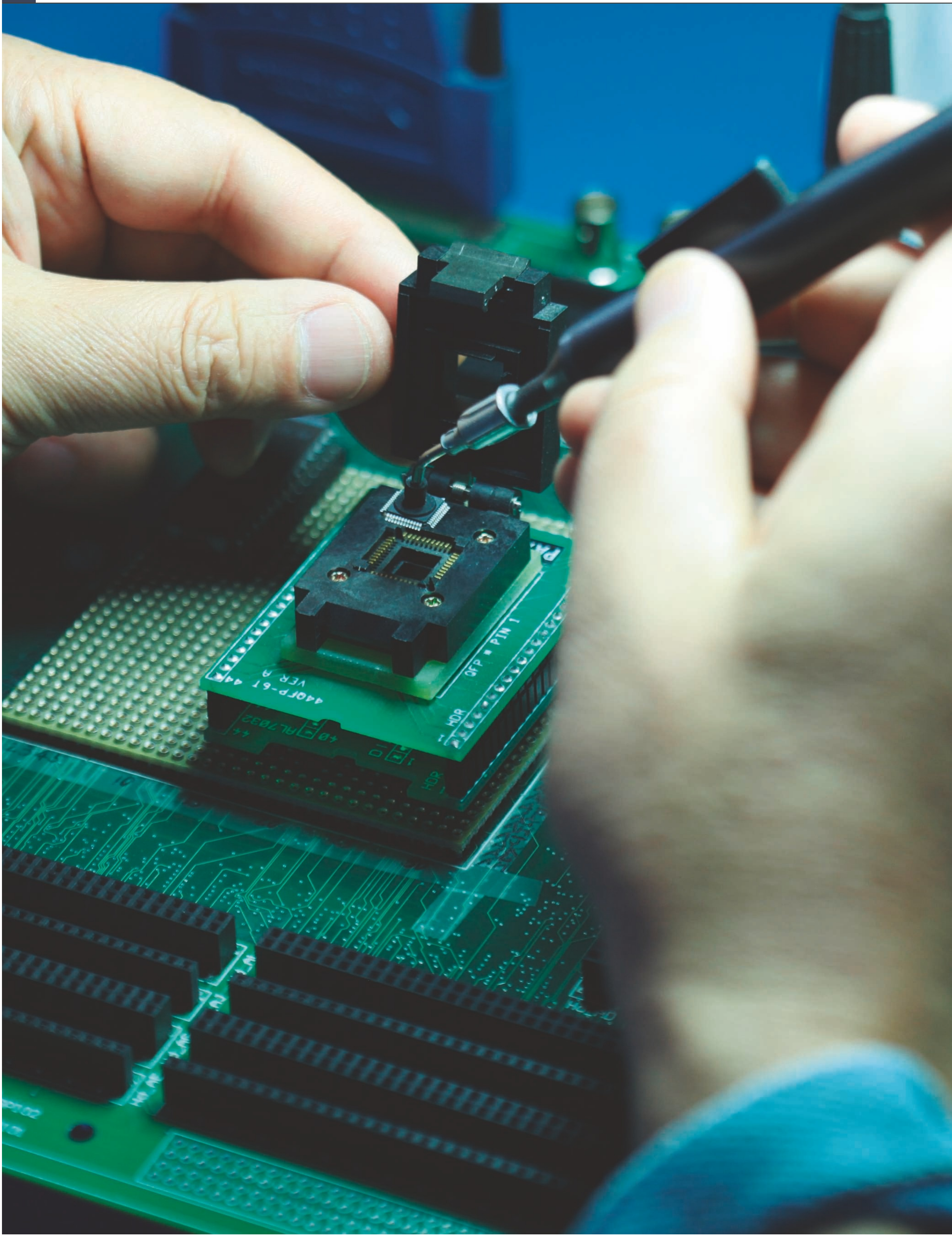
Some companies are being duped by counterfeit products. It is an easy trap to fall into because the counterfeit items available today are impeccably made and almost impossible to distinguish from the real thing. Classic Components retains its competitive edge by taking a good, hard look into any company it wishes to purchase from to ensure both the company and its offerings are legitimate.

Think of the situation like this—Your company needs a part, but none of the major, trusted sources have it in stock for at least 52 weeks. What do you do? Most turn to the internet and search for a distributor who might have the chips needed in stock. However, it is easy to set up a website and pretend to have stock that does not exist. There is also serious financial motivation with chip prices skyrocketing to produce counterfeits.

You may ask, "What happens when the online search produces a list of company names you have never heard of?" and "How do you know which are legitimate and which are not?" Classic Components knows all the players overseas. We have conducted rigorous audits and met many of the owners. We know which companies are legit and which should not be called. That is what we do.

While it might be tempting to purchase a chip from a company you have never heard of that says it has them in stock, caution is advised. If a reputable independent channel source says, "Sorry, there just aren't any of these chips available" and you have an unknown entity telling you they have them, it would be wise to listen.

An independent distributor can also offer supply chain management along with a rigorous quality inspection process to ensure the authenticity and quality of each component received. Classic Components, for



example, holds certifications such as *AS9120B Quality management systems—requirements for distributors serving the aviation, space and defense distributors*.

When the parts arrive, we know how to make sure they are good quality. The process includes conducting a detailed risk profile for the customer that takes into consideration the known reputation of the vendor, the part and the end use of the item. In addition, the customer is surveyed as to the requirements for age of the components (date codes), traceability back to the factory, etc. Classic Components has developed a scoring system to establish the risk involved in each transaction.

The process of authentication is much more extensive for higher risk profile items to ensure the chips are legitimate and high quality. There are a lot of steps, and it is very expensive and time-consuming but critical when the product is a pacemaker, for example.

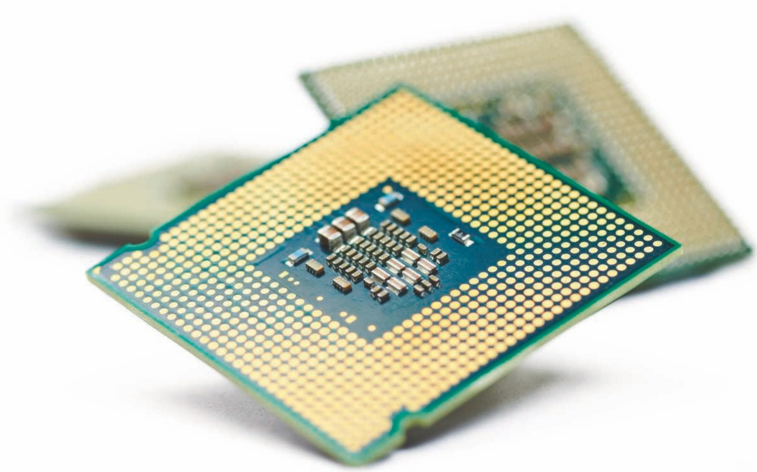
Unfortunately, for the foreseeable future, the automotive industry is expected to continue to experience significant supply chain disruptions. New technology for cars will also continue to increase demand for chips, particularly in electric vehicles and internet-connected cars.

Just as it did in 2018, the current chip shortage really reinforces the legitimacy of the independent channel. Classic Components is literally helping to keep automotive manufacturers' production lines running in some cases.

We are not thinking simply in terms of the immediate future either. Given the environment, some independent distributors have stopped stocking inventory and are demanding prepayment for components with rigid 'no cancellation and no return' policies. We still stock components and maintain flexibility in our financial terms. We want to maintain our relationship with our customers beyond the current shortage. ■

Classic Components
www.class-ic.com

"The process of authentication is much more extensive for higher risk profile items to ensure the chips are legitimate and high quality. There are a lot of steps, and it is very expensive and time-consuming but critical when the product is a pacemaker, for example."



▸ *Dental implant screws produced by Microprecisione.* ▸

Microprecisione relies on Swiss-type lathes from Tornos to deliver high-precision dental implants

Microprecisione is a manufacturer of dental implants, prosthetic systems and surgical instruments as well as biomedical products, based in Modena, a city at the heart of the Emilia Romagna region in Italy. According to Antonella Ciarmoli, general manager at Microprecisione, the company prides itself in using state-of-the-art equipment and the best materials available on the market to create precision products that are designed to cater to the needs of the customer.

The company was founded in 1993 by three entrepreneurs with a passion for precision machining and today has 42 employees. Since its inception, Microprecisione has invested in and made full use of Swiss CNC machines, or Swiss-type (sliding headstock) lathes, from Switzerland-based Tornos to produce high-precision mechanical components. These machines allow its highly qualified team to create excellent products.

The three watchwords of Microprecisione are quality, reliability and stability. As Ciarmoli herself said, "We work with specialist companies in the dental and biomedical sectors, producing innovative products of exceptional quality and reliability. Thanks to our highly qualified team, we design, develop and manufacture cutting-edge dental implant systems, using state-of-the-art technology to guarantee the high quality of our products."

Experience serving specialised customers

Microprecisione has been in Modena for three decades. Over the years, the company has continually improved on the technology it employs and today is well-known in Emilia Romagna for mechanical production excellence.

From its earliest days, Microprecisione has focussed on the dental market, specialising in the production of implants and prosthetic systems for third parties. Thanks to its constant commitment to upgrading and expanding its machinery, the company keeps pace with the latest technological developments.

In 2021, Microprecisione opened its new headquarters in Via Cavani 120, but retained the original production site in Via Del Tirassegno. The facilities between them have 12 of Tornos'

▶ *A number of Tornos' EvoDECO Swiss-type (sliding headstock) lathes at Microprecisione.* ▶

Swiss-type lathes, enabling the company to meet the individual requirements of its customers. Most of these are the current EvoDECO lathes, and the others are older models, namely the DECO 13 and Gamma.

"Our company has grown exponentially since 1993," said Ciarmoli. "In 2021, our turnover increased by 45 percent to nearly €9 million, and we have already ordered new Tornos machines, EvoDECO of course."

Key elements in the close collaboration between Tornos and Microprecisione are the competence and professionalism of Tornos area manager Massimo Lonardi. "Tornos is a reliable partner, constantly at our side, offering advice to enable us to produce certain essential parts in the field of dental implantology and prostheses," enthused Ciarmoli. "Massimo Lonardi has always been there to help in selecting the right equipment [...] to meet the needs of our company. We are delighted with this excellent collaboration."

"In 2021, our turnover increased by 45 percent to nearly €9 million, and we have already ordered new Tornos machines, EvoDECO of course."

Antonella Ciarmoli, general manager at Microprecisione

Microprecisione operates on the basis that relationships based on trust and reliability are fundamental and therefore staff turnover is very low. Ciarmoli has worked for the company for 27 years. "For women in this male-dominated work environment, it can be a real, ongoing challenge to be seen and heard as an equal," she stressed. "That said, with the support of the founding partners Ferigo Renzo and the Mucchi brothers, and by making the most of the collaborative efforts of a cohesive and competent team, we are committed to finding solutions for our customers by implementing

strategies aimed at developing and growing the company. My position of general manager is highly satisfying and allows me constantly to look into the latest innovations and continually changing technologies."

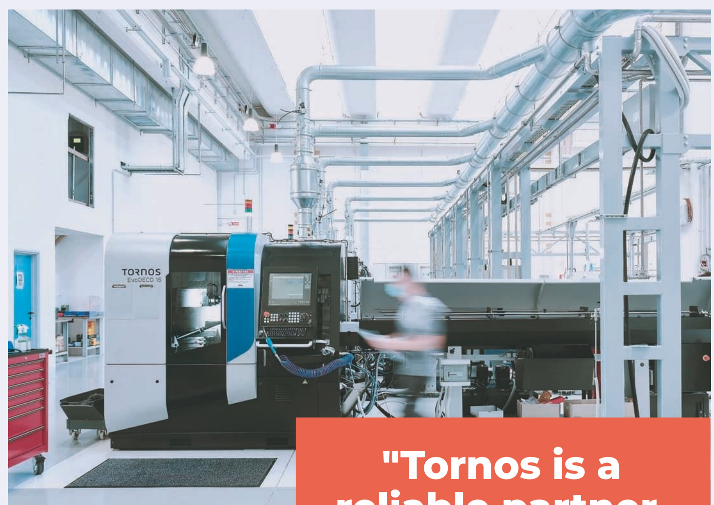
Manufacturing products that exceed expectations

Microprecisione produces a wide range of high-quality dental implants, prosthetic systems and surgical instruments to meet the requirements of professionals in the sector. Furthermore, the company designs and develops customised solutions that meet the specific requirements of customers, from small companies to large-scale distribution networks.

In the past, the versatility of the Tornos machines has allowed Microprecisione to also machine parts for the automotive and aerospace industries, as well as for printing and bonding systems.

The company creates products based on drawings or samples and often collaborates to solve any problem that might prevent a product from functioning, offering help and advice to the customer from the design stage onwards.

The main aim of Microprecisione is to provide the customer with products that exceed expectations in terms of quality. This is achieved thanks to specialised technical staff who, with modern computerised profile projectors, ensure quality control throughout the entire manufacturing process. ■



▸ *An EvoDECO 16 lathe at Microprecisione. It is used to produce a wide range of dental implants.* ▸

Microprecisione
www.microprecisione.com

Tornos
www.tornos.com/en

"Tornos is a reliable partner, constantly at our side, offering advice to enable us to produce certain essential parts in the field of dental implantology and prostheses."

Antonella Ciarmoli, general manager at Microprecisione

New horizons in motion control and precision automation technologies

SCOTT JORDAN, HEAD OF PHOTONICS, SENIOR DIRECTOR NANOAUTOMATION TECHNOLOGIES, PI FELLOW, PHYSIK INSTRUMENTE (PI)

The pace of innovation in the motion control industry has accelerated in the past decade, bringing to market fresh technologies ranging from new drive principles to new concepts in advanced controls. To the user, this has meant a steady progression of finer resolutions, higher speeds, better prices and performances, and smaller sizes. It has also meant more maturity and ubiquity of precision automated motion solutions. Additive manufacturing, for example, has commoditized to the point that appliance-class implementations with micron-scale precisions are plentiful and cheap. Even custom integrations of complicated engineered systems have been facilitated, with new open, extensible control architectures benefiting construction of arbitrarily complex applications.

> **"Additive manufacturing, for example, has commoditized to the point that appliance-class implementations with micron-scale precisions are plentiful and cheap."**

However, some advancements represent fundamental inflection-points, both for the motion control industry and, more importantly, for the applications they animate. New drive technology is one example, while other innovations fall into the general category of newly intelligent positioning. In both cases, the motion system itself becomes the enabler of an application or its economic viability.

▸ *A miniaturised integrated X, Y stage, which is driven by closed-loop ultrasonic ceramic linear motors and provides high-speed motion with 20 nm resolution over a travel range of 22 x 22 mm.* ▸ Image courtesy of Physik Instrumente (PI).

Drive technologies empower new applications

Familiar stepper-motor and direct current (DC) servomotor mechanisms are still the foundation of the motion control industry, but even these venerable drive principles have enjoyed significant advancements that have pushed applications forward. Dramatic cost reductions driven by chip-level implementations of electronic commutation (the sequencing of energising windings as the motor rotates) has democratised brushless motor designs, improving

"By replacing the bulky spindle assembly, these drives allow especially compact stage configurations with no overhanging motor assemblies."

lifetime in intensive usage by eliminating commutation brushes and their inevitable wear. The same technology has allowed linear motor stages, with their high speeds and dynamical benefits, to see increasing deployment and popularity.

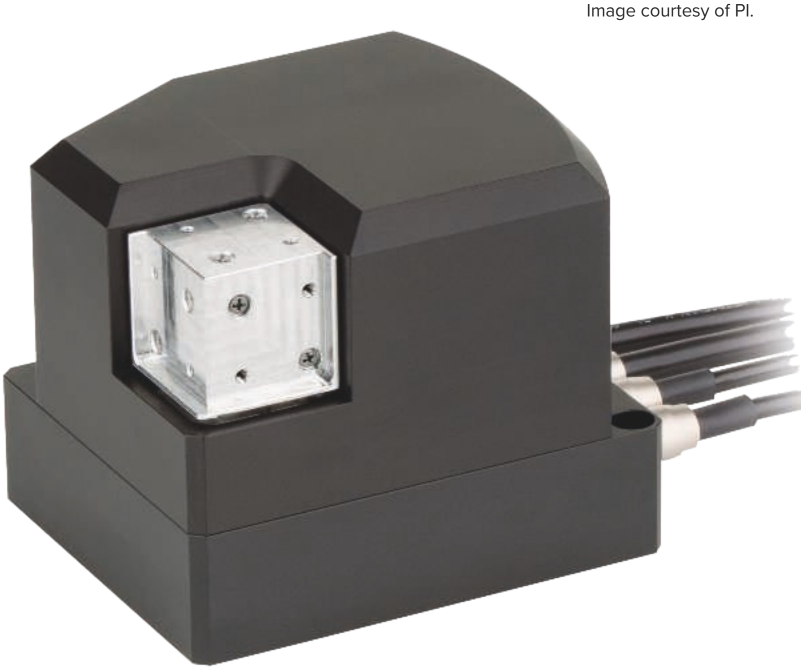
Where vendor-specific solutions were once the rule, now modular, open and standards-based control architectures, such as EtherCAT, allow integrators to build tightly synchronised and safe systems that can mix different motion technologies, with each element implemented in optimised fashion without compromise. In this way, specialised subsystems can perform targeted tasks in focused fashion in coordination with broader and often parallel actions and metrology elsewhere in the system.

Clever new drive technologies have also emerged to address tough application challenges. Piezo-ceramic technology, for example, is still essential for its exceptional nanoscale positioning capability, leveraging the subatomic-scale potential resolution and supersonic responsiveness of this fascinating class of solid-state material. These actuators remain the vital technology underlying semiconductor microlithography, with its relentlessly tightening design rules and advancing nodes.

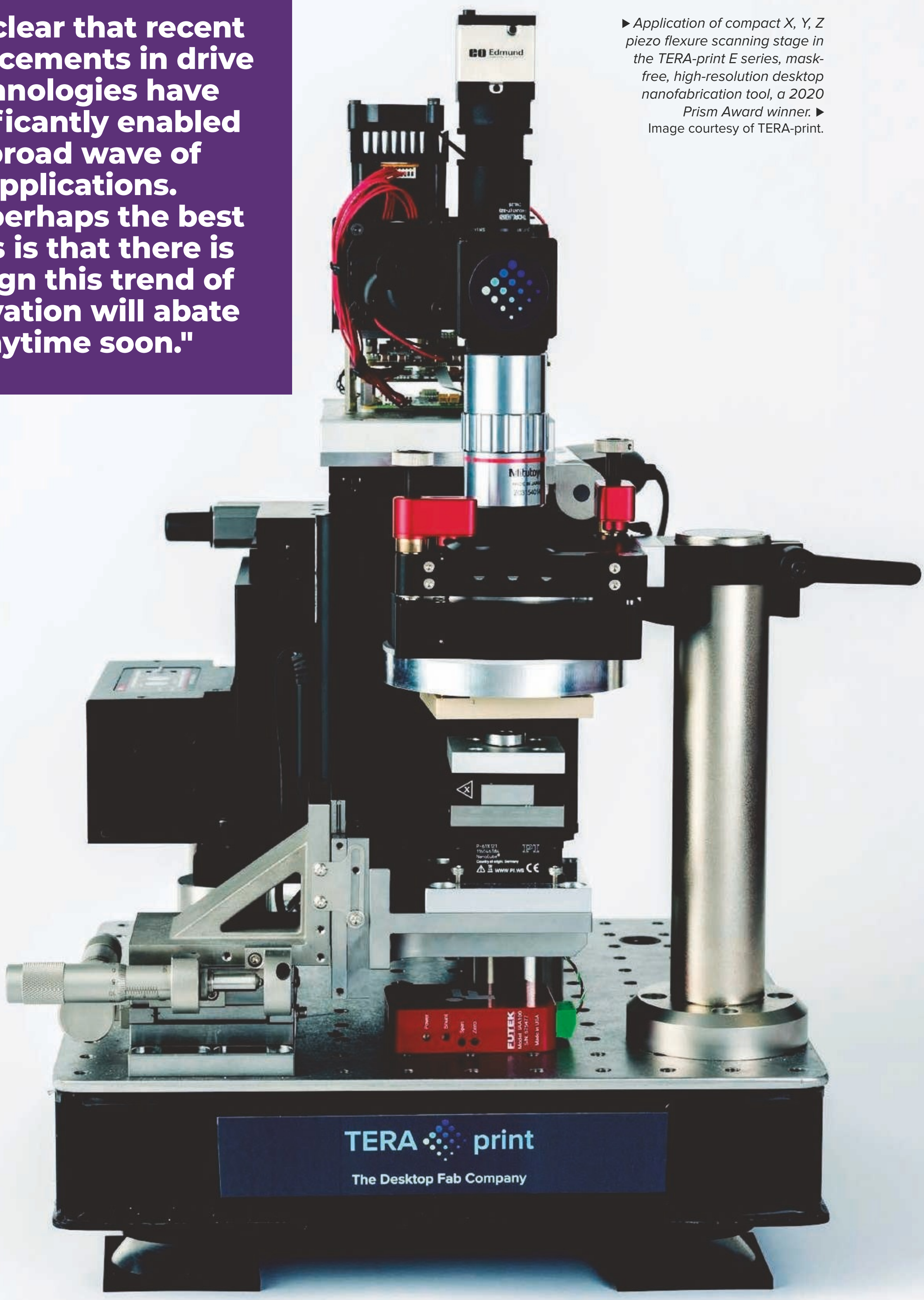
But new configurations of piezo-ceramic materials and mechanisms have surfaced in recent years, in addition to the layered stacks familiar from nanopositioning. Ultrasonic piezomotors are an example: tiny slabs of piezo-ceramic that are driven in resonance at ultrasonic frequencies, causing a pusher tip to oscillate in a micron-scale elliptical path to convey tangential force to a driven linear or rotary element. By replacing the bulky spindle assembly, these drives allow especially compact stage configurations with no overhanging motor assemblies. Speeds up to 500 mm/sec are routinely seen in stages built with these new motors, even in form factors barely 30 mm square, and elimination of a conventional spindle assembly also means that any slow, nanoscale drift caused by gradual lubricant displacement in the drivetrain is eliminated. This has enabled a wave of groundbreaking applications such as advanced microscopies in the life sciences and optical trapping in single-molecule biophysics, where the combination of speed, responsiveness and proven nanoscale in-position stability have given rise to new possibilities. As a bonus, stages based on these motors can offer reduced footprints of 30 percent or more versus legacy spindle-driven designs.

▶ *A vacuum compatible nanopositioning motor, based on a piezo inertia ratchet mechanism.*▶
Image courtesy of PI.

▶ *The NanoCube 6-axis nanopositioning and scanning stage based on piezo flexure drives. Piezo flexure stages are available with up to six degrees of freedom (DOFs), allowing fast and highly precise scanning, positioning and alignment with virtually unlimited lifetime due to the non-wear and zero-friction design.*▶
Image courtesy of PI.



"It is clear that recent advancements in drive technologies have significantly enabled a broad wave of applications. And perhaps the best news is that there is no sign this trend of innovation will abate anytime soon."



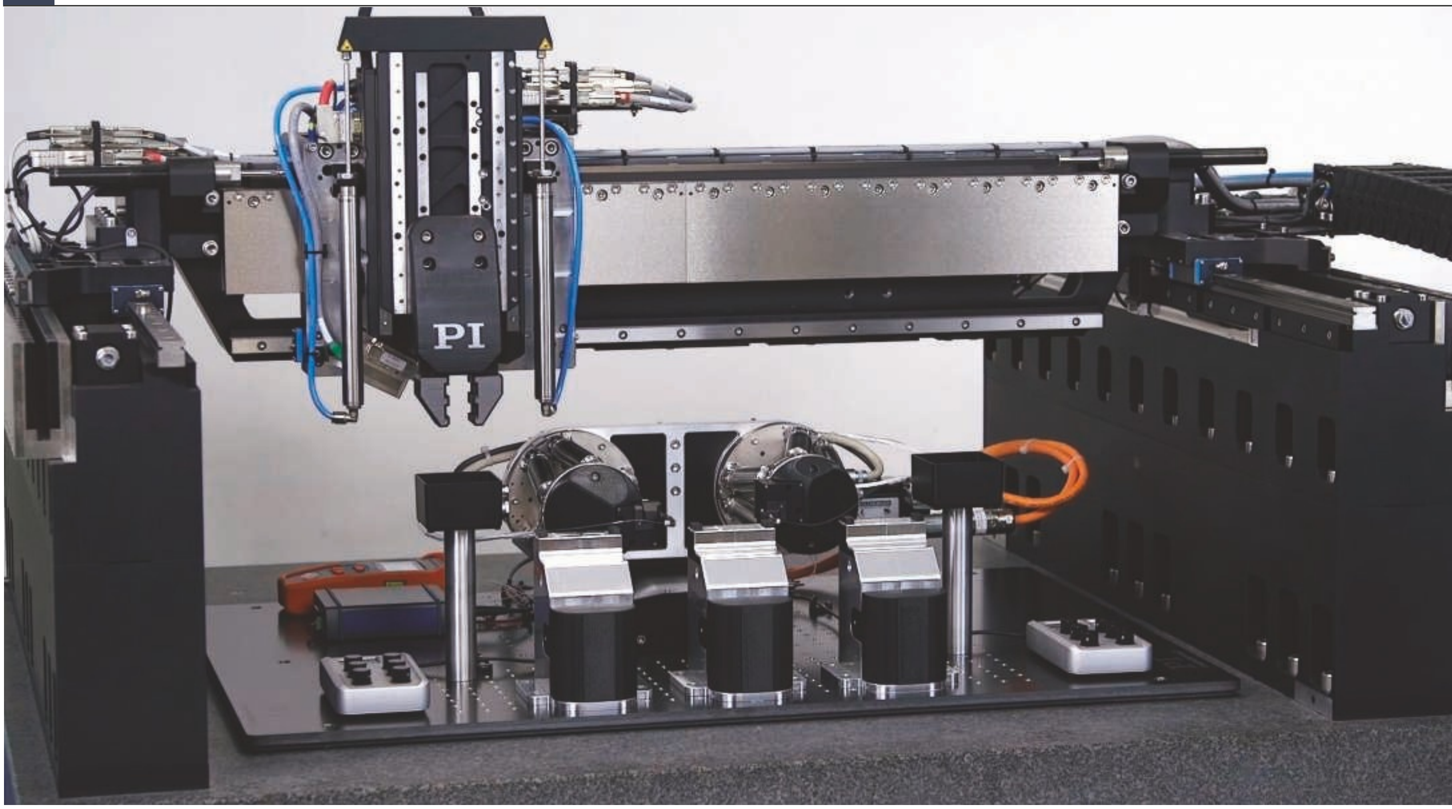
▸ *Application of compact X, Y, Z piezo flexure scanning stage in the TERA-print E series, mask-free, high-resolution desktop nanofabrication tool, a 2020 Prism Award winner.* ▸
Image courtesy of TERA-print.

Other varieties of novel piezo-based mechanisms abound. In one example, clever stick-slip drive designs combined with new, compact linear encoder technologies allow closed-loop stages the size of a lozenge to be offered, with travels of many millimetres and resolutions down to the nanoscale. Other commercial examples include a piezomotor that drives a rotary screw for automated actuation of formerly micrometre-actuated mechanisms such as mirror mounts, and long-travel walking piezo-ceramic actuators that can provide previous unattainable combinations of travel, resolution and force. Novel piezo-ceramic shims are even available now, allowing fine adjustability of leveling and spacing of sensitive assemblies with permanent stability with power removed. Add to these some clever new implementations of voice coil actuation. This straightforward type of linear motor is known for its dynamical capabilities and has recently been deployed in new ways and with new control principles to build on this foundation to provide longer useful travels and new operating modalities. Examples include a force-controlled actuator for high-throughput industrial testing of touch-driven devices, and a six degrees of freedom (DOFs) hexapod offering extraordinary dynamics for simulation and testing in camera, drone and satellite development.

It is clear that recent advancements in drive technologies have significantly enabled a broad wave of applications. And perhaps the best news is that there is no sign this trend of innovation will abate anytime soon.

Controls gain intelligence and a new applications focus

Traditional motion controllers are general-purpose devices that simply perform positioning in response to commands. The most advanced examples also implement data recorders, waveform generation, utility interfaces and macro functionalities, but the fundamental position-per-command functionality is consistent across the whole industry. Motion systems vary in architectural approach but are often differentiated by speed, resolution and similar attributes. These can be regarded as metrics of



▶ *An automated system for optical device testing based on EtherCAT control architecture, gantry X, Y, Z Cartesian robot, hexapod 6-axis motion platforms and high-speed piezo nanoprecision mechanisms.* ▶ Image courtesy of PI.

obedience: a motion system capable of positioning with nanometre resolution is basically that much more obedient than a motion system with micron-scale positionability.

Recently, however, advances in computing-power have enabled a new class of task-focused, internalised controller algorithms that speed and facilitate specific application needs. A globally significant example is seen in the revolutionary technology that addresses the need for rapid alignment of elements in testing and packaging of photonic networking products. Immense investments in data centres and networking infrastructure are ongoing worldwide, driven by the world's appetite for data, which in turn is driven by phenomena ranging from personalised medicine to Industry 4.0, to genomics, social networks, streaming media, 5G and even selfies. Between capacity and throughput requirements, as well as scalability and energy consumption, photonic solutions are essential for meeting these demands. Similarly, trends in video frame-rates and pixel density as well as new computer bus architectures have birthed a new market of high-throughput optical HDMI, USB and Thunderbolt cables for consumer and business applications.

"Between capacity and throughput requirements, as well as scalability and energy consumption, photonic solutions are essential for meeting these demands. "

Multiple studies have shown that the costs of manufacturing photonic devices are dominated by the repeated alignments needed to optimise photonic couplings for testing and packaging. Since the dawn of fibre optics in the 1980s, these alignments have been performed by slow approaches, including meandering hill-climbs, raster scans and pointwise gradient searches. With photonic devices exponentiating in complexity and production volume, these approaches posed an intractable, escalating economic roadblock to the industry. To meet this challenge, a new class of alignment automation functionalities was developed in 2016 and implemented as built-in firmware commands in powerful industrial nanopositioning and hexapod controllers. These new commands included non-stop, vibration-eliminating sinusoidal and spiral area scans, which were much faster than legacy raster and serpentine scans, and a new category of parallel gradient search that could simultaneously align multiple elements, channels and inputs/outputs in multiple DOFs, in one fast step. The reduction in overall alignment time is not small; improvements of two orders of magnitude are common. This can have a profound impact on production economics. Prime examples of implementations include FormFactor's photonic wafer probers and Tegema's integrated photonics assembly tools.

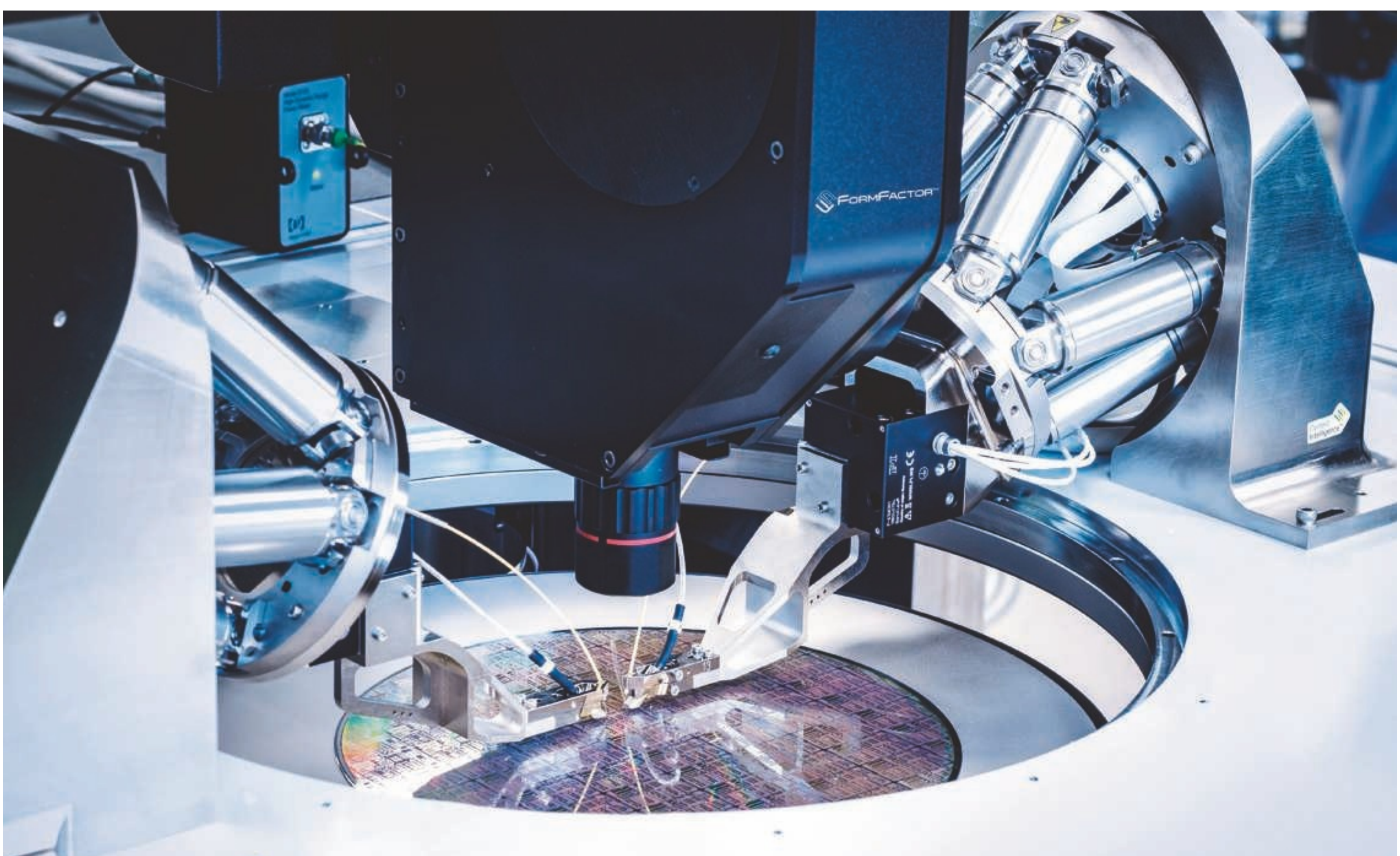
Moreover, the alignment technique is now seen to be broadly applicable, offering benefits to many other application fields well outside of photonics. After all, many manufacturing challenges boil down to adjusting or controlling positions of elements in multiple DOFs to peak up a signal or figure of merit. And so, the technology that has revolutionised the economics of photonic-device test and packaging can now do the same for applications as diverse as laser manufacturing and imaging-lens assembly.

The trends add up to opportunity

The many possible combinations of new motion drive technologies and new controls featuring autonomous, application-focused functionalities present opportunities for game-changing approaches to mission-critical applications. From the possibilities afforded by a matchbox-sized positioner with 500 mm/sec speeds, 18 mm travel and 100 nm resolution to the potential hundredfold reduction of alignment costs in photonic, optical and laser/electro-optic manufacturing, the new wave of motion innovations enables rapid and profitable progress in many fields. ■

Physik Instrumente (PI)
www.pi-usa.us

▶ *An 18-axis double alignment system integrating parallel, multi-DOFs alignment functionality to provide fast multichannel alignment of silicon photonics (SiP) array devices in wafer probers. FormFactor's CM300xi photonics-enabled engineering wafer probe station integrates PI's fast multichannel photonics alignment systems for high-throughput, wafer-safe, nanoprecision optical probing of on-wafer silicon photonics devices.* ▶
Image courtesy of Cascade Microtech, a FormFactor company.



Precision machine shops leverage adaptability and nimbleness to respond to complex medical device machining challenges

TONY DOAN, CEO, HALCYON MANUFACTURING

Within the dynamic medical device manufacturing sector, changes to part specifications and quantities are frequent and often unpredictable. As a result, clients require a machining partner who can respond adaptably and nimbly to design and production changes as they occur and be capable to scale up to lights out manufacturing when needed.

Medical device manufacturing customers may prefer large machining operations, but size alone does not equate to capacity. Smaller, precision machine shops such as Halcyon Manufacturing can have an advantage when a client needs a machining partner to be adaptable and nimble. For our clients, the ability to problem-solve by being flexible is incredibly important as complex manufacturing requirements frequently evolve and change.

Medical device machining involves a lot of low-volume, high-mix work. The reality is that not every machine shop wants to take on small orders or highly complex jobs. A client needs a machining partner who really embraces this kind of work in addition to the high-volume orders.

When evaluating the capacity of a precision machine shop, the capability to respond to changes in specifications and production quickly becomes a key factor.

Building capacity through cross-training

Staff cross-training is one way a machine shop can improve their ability to respond to unexpected and time-sensitive machining needs. While today's machine shops are filled with a mix of high-tech precision CNC equipment, each requires trained staff to manage, maintain and operate.

A lot of machine shops will assign an operator to a specific CNC machine. This can create a situation where a particular operator has to be available and not working on other orders to operate a given machine.

Having the ability to move people from machine to machine, as well as from line to line and from shift to shift, without interruption, enables a machine shop to respond to changes in demand more quickly.

"At Halcyon, where bar grade 6061 aluminium, brass, copper, titanium, stainless steel and plastics are machined, we have cross-trained our entire staff to work across all equipment to maximise our capability for scale up."

At Halcyon, where bar grade 6061 aluminium, brass, copper, titanium, stainless steel and plastics are machined, we have cross-trained our entire staff to work across all equipment to maximise our capability for scale up.

In addition, we all work multiple shifts, and we have the same controls throughout our shop, making it easy for our people to be able to move around as needed. So, when a client needs something over a weekend, we don't have to completely rethink how we're going to schedule. We can easily plug in people for surge hours or to increase our manpower as needed.

The company made the decision to further enhance cross-training through our selection of machining equipment. Unlike shops that purchase a variety of types and brands of CNC equipment over time, Halcyon intentionally purchases the same model of high-end, 5-axis CNC machine from Doosan Machine Tools with FANUC controls as they expand. This further reduces the learning curve for staff.

Lights out manufacturing capability

Adaptability and nimbleness are also needed to be able to scale production up quickly. Some machine shops such as ours operate on a 24/7 basis, enabling customers to connect with them outside of traditional office hours. It takes scaling up production to the next level. CNC operators can set up the equipment to run on its own without supervision overnight.

Lights out manufacturing capability means smaller shops can maximise their capacity without adding more staff.

It starts with culture

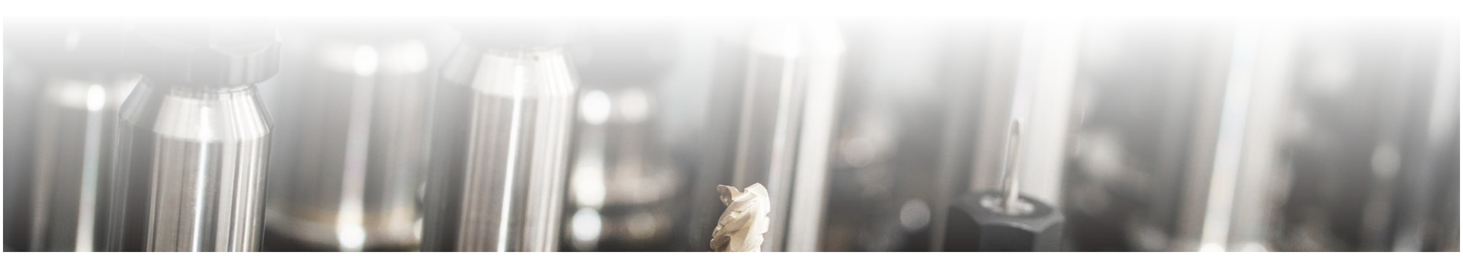
The mindset that a machining partner brings to precision medical device machining is also critically important. It starts with the culture of the shop and the problem-solving mindset they bring to a project, particularly for complex, precision parts. You also need a machining partner to be proactive. By engaging early in the process, a machine shop can anticipate and resolve machining issues before any parts are produced.

Recently, a customer approached Halcyon with what appeared to be a simple job that other machine shops had turned down. The part had a 6 in. threaded shaft with a hex head. There was an 832 thread across the outside diameter (OD) of the shaft. Most lathes are not able to cut those threads across six inches. We had to get creative since we could not use round stock, which is generally used when cutting OD threads.

We determined how to form the thread while accounting for the growth that occurs when the thread is formed on plate steel to meet the tight requirements. For it to run on a CNC machine, we also had to create a modified thread using a cut die. We were able to meet the client's deadlines with parts that met specifications.

Adaptability and nimbleness in precision machining represents a key consideration for medical device clients as they seek partners to provide solutions to their complex design problems and production scale-up needs. Through cross-training, lights out manufacturing and a problem solving, proactive mindset, smaller machine shops are well-equipped to meet the demand. ■

Halcyon Manufacturing
www.halcyonmfg.com



EVENTS

CONTROL
May 9–12, 2023
Messe Stuttgart, Germany

An international trade fair for quality assurance.

www.control-messe.de

SENSOR+TEST
May 9–11, 2023
NürnbergMesse, Germany

A leading forum for sensors, measuring and testing technologies worldwide.

www.sensor-test.de

mAm, Micronarc Alpine Meeting
May 15–16, 2023
Villars-sur-Ollon, Switzerland

The Micronarc Alpine Meeting is a two-day conference with a focus on equipment for manufacturing microproducts.

www.mam2023.ch

EPHJ
June 6–9, 2023
Palexpo, Geneva, Switzerland

A trade show that brings together all high-precision skills in the areas of watchmaking and jewellery, microtechnology and medical technology.

www.ephj.ch

Laser World of Photonics
June 27–30, 2023
Messe München, Germany

A leading trade fair for components, systems and applications of photonics.

www.world-of-photonics.com

SEMICON West
July 11–14, 2023
Moscone Center, San Francisco, US

A show covering the entire extended microelectronics supply chain.

www.semiconwest.org

The Nanotechnology Show
October 3–4, 2023
Greater Columbus Convention Centre, Columbus, US

An industry-focused exhibition and conference covering the development and integration of nanotechnology within a range of applications including aerospace, automotive, electronics, energy and medical technology.

https://nanotechnologyshow.com

SPIE Photonics West
January 28–February 02, 2024
Moscone Center, San Francisco, US.

An event for lasers and other light sources.

www.spie.org

SIAMS
April 16–19, 2024
Forum de l'Arc, Moutier, Switzerland

A trade fair for microtechnology production tools.

www.siams.ch

Medical Manufacturing Asia
September 11–13, 2024
Marina Bay Sands, Singapore.

A leading specialist trade fair for Asia's medtech and medical manufacturing process sectors, covering new materials, components, intermediate products, packaging and services, micro- and nano-technologies, and testing systems and services.

www.micronora.com

MICRONORA
September 24–27, 2024
Besançon, France

A trade fair that brings together the entire microtechnology sector. Trades include additive manufacturing, assembly/microassembly, automation/robotics, CAD/CAM, laser technology, metrology, microelectronics packaging, micromachining and micromoulding.

www.micronora.com

If you would like to see your event listed here, please contact Michael Taylor at cmm@cmmmagazine.com