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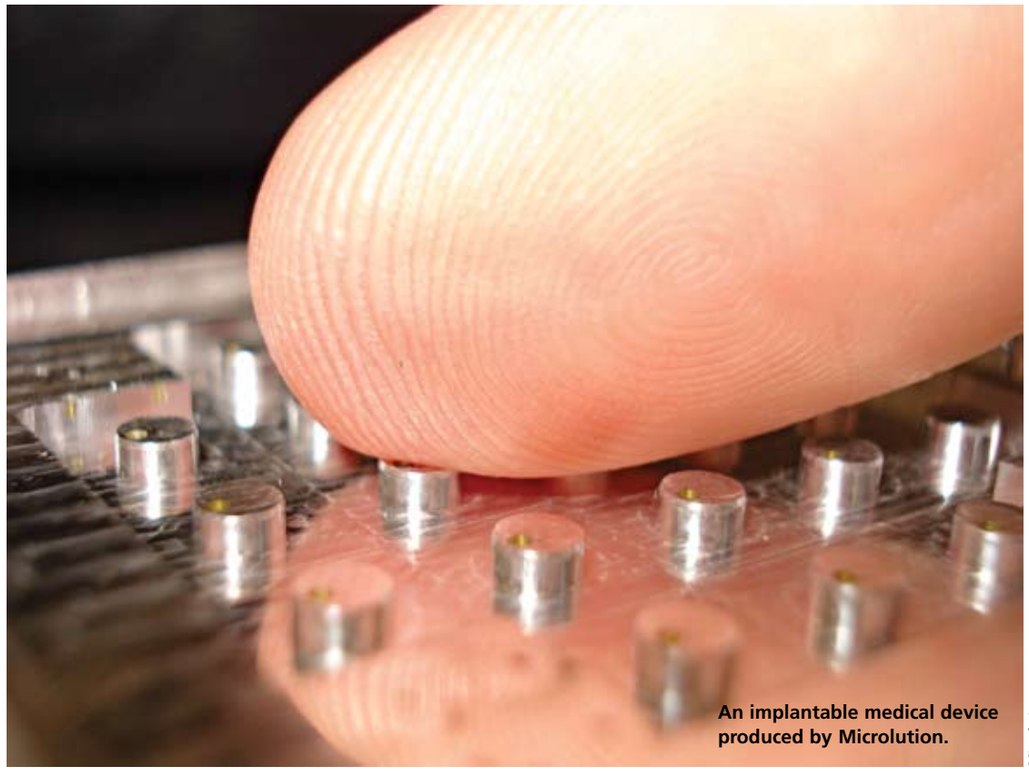
➤ BY ALAN RICHTER, EDITOR

Right Sized

As the micromanufacturing industry grows, a machine tool builder targets the sector with a milling machine designed for small parts production.



An implantable medical device produced by Microlution.

Microlution

The "city of the big shoulders" saw its manufacturing community grow when a machine tool builder set up shop to target the production of small parts and features.

Andy Phillip, president, and Andrew Honegger, vice president, recently established Chicago-based Microlution Inc. to build advanced micromanufacturing systems after completing a graduate program at the University of Illinois headed by mechanical engineering professors Dick DeVor and Shiv Kapoor.

Phillip noted that the graduate program integrates micromachining theory and hands-on work that includes designing and building prototype machines specifically for machining high-precision small parts. "That mix was ideal for me," he said. "As soon as they described the research, I was sold."

During their graduate studies, Microlution's founders helped build five prototype micromachining tools. Being prototypes, the machines didn't have features necessary for a production environment, such as chip guarding, and "the electronics were basically a pile underneath the bench," Phillip said. "It was really just a development platform."

Nonetheless, Honegger and Phillip received positive responses when they presented one of the machines they developed at the Emerging Technologies Pavilion during IMTS 2004. "A number of individuals came by and said, 'I could use this. When can I get one?' Not too many people had to say that before a light bulb came on in our heads and we said we should probably try to do something about it," Phillip recalled.

Initial Offering

After completing the graduate program and establishing the company in a somewhat dicey neighborhood, Microlution moved to a 4,100-sq.-ft. facility on the city's northwest side. There, the machine tool builder continues to assemble its Model 310-S 3-axis horizontal micro milling machine. In contrast to the prototype design, the commercial version has sheet metal guarding, air-tight rubber bellows for the chip shields so bearings don't become contaminated with tiny chips, electronics integrated into circuit boards, higher resolution encoders, and precision-ground granite substructures upon which the X, Y and Z stages are built. "We developed this machine based on the principles we were studying," Phillip said. "We were able to leverage this very unique, focused work that came out of the University of Illinois on making small, accurate parts."

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Andy Phillip, Microlution's president, next to the company's Model 310-S 3-axis micro milling machine.

The 310-S is for producing prototype and low-volume parts less than 2½", the dimension of the working volumes for the X, Y and Z axes. The machine costs less than $90,000, has 2-micron positioning accuracy and 0.02-micron resolution.

The machine comes standard with a 160,000-rpm air-powered spindle, and Microlution offers additional spindles as options, depending on the customer's speed, torque and accuracy requirements. Phillip noted that there's a "balancing act" regarding spindles when machining features down to the tens of microns with tools potentially as small as 10 microns in diameter. "You need high speed to have the proper cutting parameters for a given workpiece material and tool material," he said, "but you also need to maintain a steady, vibration-free cutting operation."

The Microlution 310-S uses a unique ball and V-type kinematic mounting interface for both the workpiece and the spindle. The interface provides six points of contact between the workpiece or spindle and the machine. With six points of contact, the mounts are exactly constrained and therefore self-locate to the same position each time they are mounted. This allows the workpiece or spindle to be removed and replaced with submicron repeatability. This capability allows, for example, an operator to interrupt a machining operation and remove, inspect and replace the workpiece without the need to reregister the part.

In a situation where the machine is being used for multiple applications, each application can have its own kinematic workpiece pallet. This enables multiple users to easily transition from one setup to the next without losing part registration. "That's critical for small parts because it's so difficult to register the parts in general," Phillip said.

The kinematic mounting system also allows the end user to remove and replace the spindle with, for example, a laser distance sensor to perform metrology operations, such as measuring surface roughness and surface profile. Similarly, multiple spindles—each with its own kinematic spindle mount—can be accurately implemented during a single machining process.

Miniature Cutting Tools

Few machines on the market are optimized for micromachining, primarily because the standard practice is to start with a conventional machine tool originally designed for larger parts and enhance the machine with higher end components to increase the accuracy needed for small parts and small features, said Phillip. These enhancements include high-resolution encoders, higher precision bearings, higher accuracy ballscrews, backlash compensation algorithms and thermal compensation mapping.

Cutting tools for micromachining, on the other hand, are readily available from a host of toolmakers. "There is quite a range of configurations available off the shelf," he said, including flat, ball, extended reach and 2- and 4-flute tools. "People are using these cutting tools to make small parts on big machines that really are not optimized for micromachining. That's where we think our technology has a huge advantage and can help a lot of manufacturing operations."

Not only are miniature cutting tools readily available, but toolmakers understand micromachining requirements and design the tools accordingly. For example, while a 5-micron edge radius on a macroscale tool is sharp compared to the 100- to 200-micron chip load it's taking, that isn't the case when micromachining.

"The microscale tools that we use have that same 2- to 5-micron edge radius, but we're taking chip loads of 1 to 3 microns per flute, so all of the sudden the tool looks very dull relative to the process we're trying to perform," Phillip explained.

If chip load is reduced below the threshold for a minimum chip thickness, the tool is no longer forming a chip. "Then you just rub the tool past the surface," he said. "You burnish the surface and wear out the tool, making for poor accuracy and surface finish."

To prevent that, a machinist must maintain a particular feed rate for a specific spindle speed to achieve the required chip load, which dictates a specific acceleration to achieve that feed rate. [The formula for chip load is feed rate (ipm) divided by rpm times the number of cutting teeth.]

"Every tool pass that occurs below that feed rate just makes waste," Phillip said. He added that a machine tool requires high acceleration to maintain those cutting parameters when making small parts. The Microlution 310-S offers 5Gs of maximum acceleration along each axis of motion, compared to 1G or 2G for conventional machines, according to Phillip.

Producing Parts

In addition to building machine tools for micromachining, Microlution produces prototype parts and performs contract manufacturing

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Microlution's Model 310-S micro milling machine is for producing parts less than 2½" in size.

using its machine. Production ranges from prototype medical parts made of plastic, which eliminates producing an expensive mold, to runs of up to 100 parts made of various metals, including hardened steel, stainless steel, aluminum, ceramics and glass. "We got a quote out on a 300-part run," Phillip noted, but added that shorter runs are better suited for demonstrating the machine's capability.

That's because building machines remains the company's primary business. "We run the machine in-house [to make parts] primarily as a proof of concept," said Onik Bhattacharyya, Microlution's sales and marketing coordinator. "The best way to show somebody what our machines can do is through applications where they're having difficulties."

Nonetheless, Phillip said the prototyping and contract manufacturing side of the business has been doing well and Microlution has added a second machine for that work. "The number of inquiries has been growing rapidly," he said.

In addition to the machine's 3-axis milling configuration, Phillip noted that a turning module is possible by reconfiguring the 310-S. The company is also planning on offering new products. Toward the end of the year, automated tool and pallet changing will be available. Also, Microlution plans to introduce a 5-axis machine in 2008.

The company has five employees but is looking to expand. Phillip said: "We have a vision to make this company very large. We've seen many times that there's a huge need for this technology and there's a tremendous amount of value that it can provide. We're constantly looking toward the future and continuing to ramp up, expand and address that need." △

For more information about Microlution Inc., call (773) 282-6495 or visit www.microlution-inc.com.

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