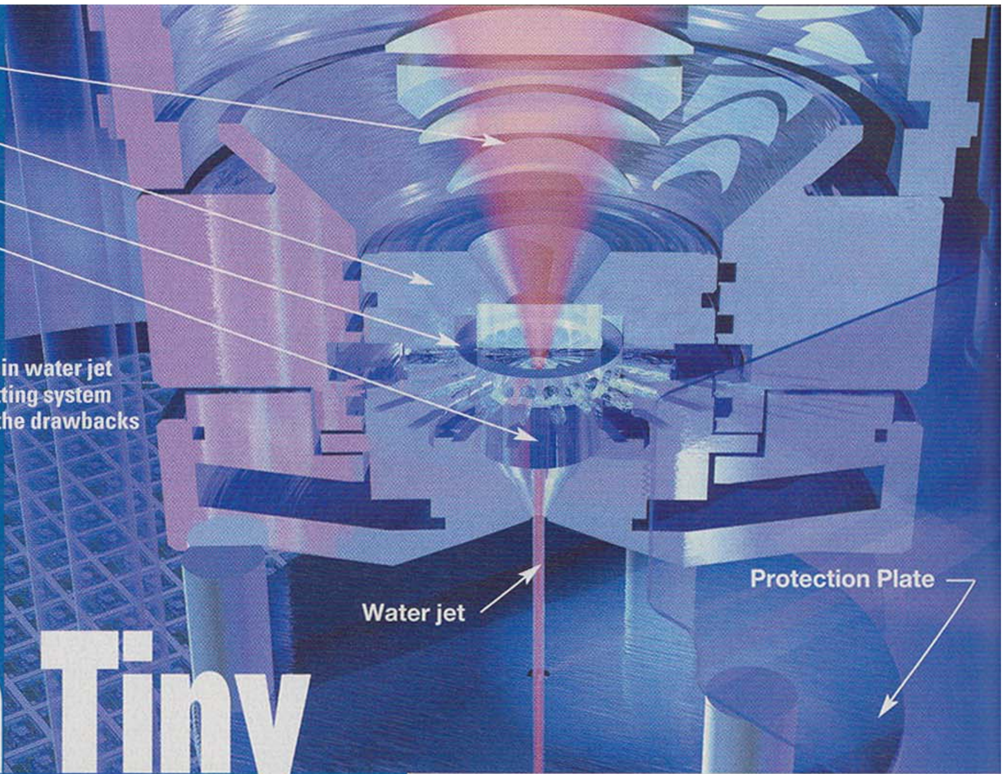


Firing a laser beam into a hair-thin water jet produces Synova's precision cutting system that works cleaner and without the drawbacks of a laser or water jet alone.

How to Form Tiny Details on Small Parts

Cutting with a laser in a water jet, photo etching, and building mechanisms in micro layers are three methods for accurately manufacturing really small parts.

Paul Dvorak
Managing Editor

As medical devices shrink to handle lower-power requirements, demands for portability, and to fit within the human body, researchers are developing new production ideas and updating a few older ones to accurately handle the smaller dimensions.

The micromachining methods selected for this review include a process out of Switzerland that combines a laser in a thin water jet to cut metals cleanly and precisely, and without thermal loading. Another produces mechanisms in metal that can be measured in microns. And photo etching, a process that has produced burr-free parts from a variety of metals, now works with plastics.

Laser in a waterjet

Medical products need clean surfaces and smooth edges, so manufacturing processes used to make them should make accurate cuts and inflict no thermal loads that might warp parts. A water-jet guided laser, Laser Microjet from Synova SA, Switzerland, (*www.synova.ch*) focuses the beam into a nozzle attached to pressurized water chamber. The water jet and laser exit the nozzle together and hit the stock. "Unlike laser-only technologies, adding the water jet makes Laser Microjet clean and gentle," says Roy Housh, product manager at the company.

"Water's momentum washes away ablated materials eliminating dross and burrs. In addition, the circular water jet makes for perfectly parallel kerfs and allows relatively long working distances, up to several centimeters, depending on nozzle diameter. And the force applied by the jet is negligible, less than 0.1 N," he says.

The laser is either a flash-lamp pumped pulsed Nd:YAG version with pulse durations shorter than 120μs, or a multimode Q-switched laser, operating at 1,064 nm, 532 nm, or 355 nm. The water jet uses pure deionized water pressurized from 50 to 500 bars. The hair-thin jet (25 to 100 μm) consumes only about 1 liter/hr, despite its 200 m/s speed at 300 bar. Nozzles are sapphire or diamond to generate long stable jets.

"Stent cutting, the major application, is difficult because of the stent's complex and intricate structures, and tight tolerances," says Bernold Reicherzhagen, CEO of the company. "These devices also need clean curves, and no cracks, dross, or burrs. Low thermal loading is essential because stent materials usually are heat-sensitive stainless steel or shape-memory alloys. And although laser cutting usually requires post-processing steps, such as sand blasting or electro-polishing to remove burrs, depositions, and heat-affected zones, the water-jet-guided laser produces easy-to-remove, non-adhering dross along back edges so post processing is minimal," says Reicherzhagen.

Another application sharpens surgical blades. If the cutting-edge is etched, other shapes on the blade (external contour and slots to fix the blade) are made by laser. Abrasive sawing cannot be used because it rounds edges. Requirements for cleanliness eliminate conventional lasers because they generate too many particles and burrs. Water-jet guided lasers, however, avoid these drawbacks.

Measuring in microns

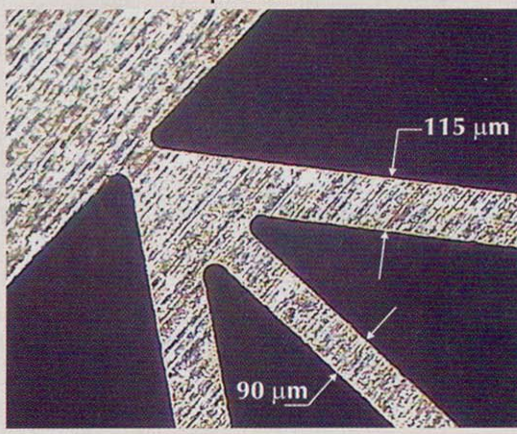
The Efab method builds mechanisms layer-by-layer with micron precision out of familiar metals, such as nickel, nickel alloys, and copper — materials that electrodeposit well. Silver, gold, platinum, and stainless steel may be possible in the future. One nickel alloy that works well is believed to be biocompatible, subject to testing. **Microfabrica**, Burbank, Calif., (*microfabrica.com*) has extended Efab to where it can create layers from 2 to 50 microns thick. The previous height maximum was 12 microns. This lets Efab build taller micro devices than were previously possible and as a lower-cost alternative to high-aspect-ratio micromachining, such as LIGA. Thicker layers benefit applications such as inkjet printhead nozzles, inertial measurement units, and magnetic microsystems.

"Fabricating thin structures such as springs, cantilevers, and diaphragms in the same device along with thicker structures has always been a problem with conventional micromachining," says Adam Cohen, EVP of technology with the company. "For example, we're building a hydraulic actuator embedded within a 0.5-mm hose barb. The whole actuator fits within the 0.5-mm diameter, so it's possible to build a surgical tool at the end of a catheter that could be actuated hydraulically. We're also building a filter that could be used on biological fluids such as blood. It has a tightly controlled porosity, equivalent to the best membrane filters but with greater durability and rigidity."

Small mechanisms and MEMS, micro electro-mechanical systems, to be built by the process can be quickly designed with standard 3D CAD software. Component libraries can be used to design complex microsystems built in a single process, and product changes do not require manufacturing process changes. The process can build many different microdevices on the same substrate to accelerate product development. For example, a 4-in. dia. wafer could hold up to 25,000, 0.5-mm^2 devices.

Efab lets engineers design and build al-

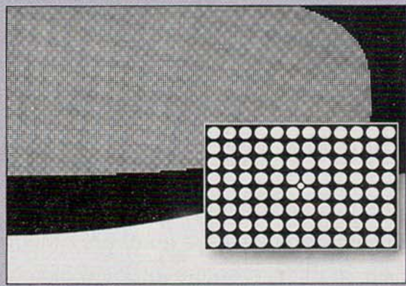
A stent made of 250-μm thick stainless-steel sheet has not been cleaned after cutting. Compared with conventional laser cuts, this one is much cleaner. No burrs or particles are visible. Oxidation is also absent and the contour is precise.



Think lasers for medical metals

Lasers are still the workhorses when it comes to detail and precision in micro machining, especially for metals that are not manufactured easily by other methods, says Jeff Miller, manager of laser R&D at **Norman Noble Lasers,** Highland Hts., Ohio, (*normannoble.net*). "For example, other processes have difficulty with medical materials, such as platinum/iridium and Nitinol, but lasers cut them easily," he says. "The trick to cutting platinum/iridium and Nitinol is to cut them cleanly without the presence of dross or an oxide layer where hydrogen embrittlement can occur, and anywhere the metal might flex," he adds.

Post-laser finishing is critical for smooth finishes so Miller's company developed an electropolishing process that works well with batches of up to 50 parts. "It removes metal up to about 0.0005 in. from all surfaces, he says.



As an example of a laser's accuracy and tolerances, Miller suggests examining this non-medical part made with over 19,000 laser-machined holes, 0.035-in. +/- 0.0001-in. diameter, with a true position of 0.0001 in. for each hole.