

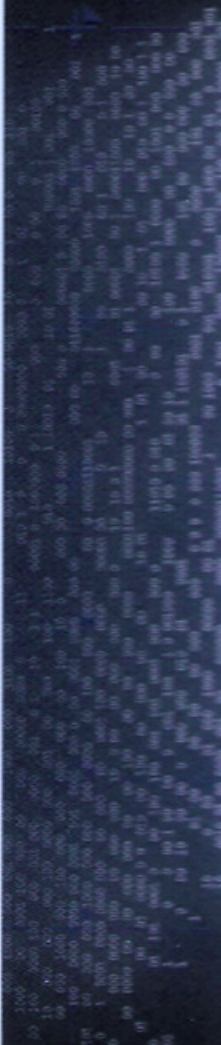
serving european medical device and in vitro diagnostic product manufacturers

# medical device technology

techniques for  
ear surfaces

pages 12 and 22

**FAULHABER GROUP**



## MARKET PLACE

### Laser Tube Cutting With Minimal Kerf

Fiber lasers are being combined in cutting workstations to enable micron-accuracy cutting of micro components and tubing with minimal kerf.

#### The requirements

Accurately guided laser cutting with minimal kerf is important when micro-processing numerous materials. In most applications, the items to be processed are expensive micro-components and there is not much room for error. Cutting to micron accuracy does, however, allow finer details to be realised in a manufacturing process and can also mean less waste. To achieve this level of precision the laser, the optical assembly, and mechanical handling of the component being processed must operate at the highest level of optical and physical stability. Fiber lasers can fulfill these requirements in many applications, having matured over the past few years into robust industrial tools. They now offer a unique series of capabilities, including stability of the output power, the focused spot size, and economic benefits.

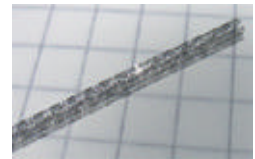


Figure 1: A finished stent structure. Tube diameters can be below 2 mm, wall thicknesses below 0.2 mm.

#### Micro-cutting with lasers

Small components with small material thicknesses usually cannot tolerate excessive vibration and are not always suitable for motion control around a physical cutting tool. The laser obviates these problems by providing a vibration-free, stand-off cutting method. The use of a laser does, however, require proper handling of other aspects of the cutting process such as the heat-affected zone (the area immediately around the cutting zone). Here, heating taking place through diffusion must be minimised to avoid thermal damage to neighbouring materials such as plastics and (electrical) components.

In addition, with laser cutting it is essential to determine the best laser parameter space for the material in question so that the finish is good and dross and kerf are kept to a minimum. This places strict requirements on aspects such as laser output stability, mechanical motion control and laser beam delivery. Despite these issues, lasers enjoy a strong position in the industry and are widely used for cutting small tubing such as stents. These products are expanded within blood vessels to improve blood flow and provide mechanical support for the vessel walls (Figure 1). They must, therefore, be mechanically robust, exhibit predictable performance and possess high surface finish.

#### Requirements for a quality cut

Minimising the kerf width and improving the quality of the cut (correct contour and good initial surface finish) requires specific equipment:

- The laser source must be reliable and flexible in its power delivery. An unstable power output, inappropriate power delivery and a low quality output mode all independently contribute to a poor quality cut with wide kerf.
- The optics responsible for delivering the laser power to the workpiece and the final focusing optic must be of the highest standard to ensure the best focal spot.
- The motion system handling beam steering and movement of the workpiece under the beam focus must maintain the intended beam path without introducing excessive mechanical "noise."
- The optimum cutting parameters at a given cutting speed and the choice of wet or dry cutting to ensure proper thermal management during cutting. Wet cutting can be beneficial for small components in general. Small metal items heat up quickly and it is crucial to keep the temperature of the heat-affected zone to a minimum, especially because heat diffusivity increases with temperature. Wet cutting helps maintain better thermal management in the workpiece and helps prevent backwall damage. Although a wet-cutting process is not always practical to apply, it is suitable for tube cutting because water (often treated to inhibit corrosion) can be pumped through the inner diameter.

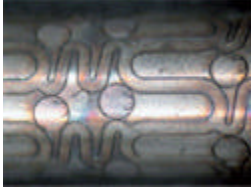


Figure 2: The path followed by the laser. The kerf width of 12  $\mu\text{m}$  is obtained in a 1.8 mm tube with a wall thickness of 0.14 mm. Process optimisation will avoid minor thermal discolouration.

## Workstations utilising fiber lasers

These requirements have been brought together in recently developed cutting workstations (Swiss Tec AG, Schaan, Liechtenstein). Eduard Fassbind, the company's Chief Executive Officer, maintains that the achievable kerf width is reliable at 10–12  $\mu\text{m}$ . This is obtained, he says, by employing specific components in the workstation. These include 50 W or 100 W fibre lasers (SPI Lasers, Southampton, UK), proper beam handling in association with a custom-designed optic for the final focusing, a high resolution motion and handling system mounted on a solid granite base.

Figure 2 shows a cut stent immediately before separation from the excess metal. Automated quality control assessment of the cut profile reveals that the contour of the cut is accurate to 64  $\mu\text{m}$ , which is achieved at a cutting speed of up to 700 mm/min and with minimal thermal discolouration. The quality of micro-cutting obtained with the fiber laser reduces the subsequent degree of electro-polishing that is necessary to give blemish-free surface and edges.

The workstations are also capable of cleanly cutting 250- $\mu\text{m}$  thick cobalt chrome or Nitinol at speeds of 800 mm/min, and stainless steel hypo-tubing of 300- $\mu\text{m}$  diameter at speeds of 1000 mm/min, according to Fassbind. He continues, "Cutting speeds of up to 1000 mm/min are realistic with the 50 W laser and we can also cut titanium at approximately half this speed, although we have not finished optimising the process yet. Wall thicknesses of more than 250  $\mu\text{m}$  will need to use a 100 W laser, but even with the extra power we can still maintain identical kerf widths."

To help optimise the cutting process, the workstations include a motorised beam expander, a charged coupled device camera looking directly down the nozzle at the cutting area, the ability to pass fluid or process gas through the stent tube for cooling, and fine lateral and vertical pre-positioning of the nozzle and laser beam over the work piece. Fassbind adds, "One of the most significant contributions is the fiber laser itself."

## Advantages of fiber lasers

When it is important to maintain narrow kerf and proper cut contour, fiber lasers excel through a combination of performance-related parameters. Power variation, for example, is below 60.5% even at low powers, and is maintained while providing flexibility in the power delivery (pulses from  $\mu\text{s}$  to continuous wave). The consistent TEM00 beam (Gaussian beam profile) maintains a constant focal spot size in the cutting plane. The small spot size and high beam quality translate into high irradiance at the focus to enable low and reliable (average) power cutting of thin wall thicknesses. Precision cutting can be performed close to (0.1 mm) the most complicated and intricate component parts. Fiber lasers also minimise operational costs because there are no requirements for lamp changes, alignment and calibration. They exhibit longer up-times than alternative laser technologies because they inherently need less maintenance and thereby ensure less scrap.

These advantages mean that fibre laser technology is frequently chosen over conventional flash-lamp-pumped solid state or diode-pumped solid state laser technology. There is a growing acceptance of fiber lasers as a cost-effective, often plug'n'play alternative to conventional laser design. When the technology is employed in micro-processing workstations, it also means that the user can focus on business demands, rather than having to become a laser maintenance expert.

## Acknowledgements

The authors gratefully acknowledge contributions from Dr.-Eng. Michael Giese, C.E.O. eucatech AG, Rheinfelden, Germany ([www.eucatech.com](http://www.eucatech.com)).

**Eduard Fassbind** is CEO, Swiss Tec AG, Schaan, Lichtenstein, tel. +41 41 790 3385, e-mail: [e.fassbind@swisstecag.com](mailto:e.fassbind@swisstecag.com), [www.swisstecag.com](http://www.swisstecag.com), **John Tinson** is Vice President Sales, SPI Lasers UK Ltd, Southampton, UK, tel. +44 1489 779 668, e-mail: [john.tinson@spilasers.com](mailto:john.tinson@spilasers.com), [www.spilasers.com](http://www.spilasers.com), **Gregory Flinn**, Putting Photonics into Context, Munich, Germany, tel. +49 8995 4204 57, [www.gregoryflinn.net](http://www.gregoryflinn.net)