Fine Cutting With Lasers

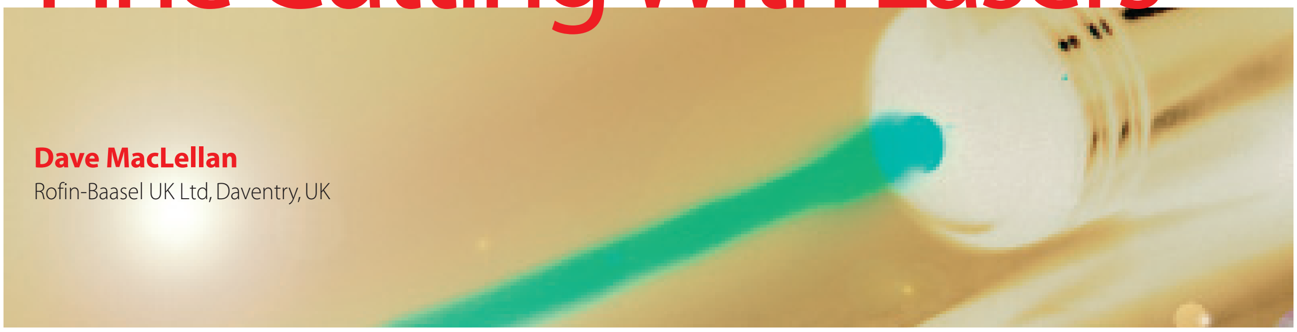

Image: Photodisc Inc.

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Laser processing is often the best production technology for components made from small-diameter tube or flat sheet foils. The capabilities of different types of lasers are described.

Reasons for choosing a laser

The continuing miniaturisation of medical devices means that there is a fast-growing need for new production equipment capable of producing subminiature finished parts by cutting, drilling, ablation or etching. The laser is an ideal tool for many micro-sized components (Figure 1).

Today's designer can specify manufacturing by laser whether the material is hard or soft, and the noncontact nature of laser cutting allows the finest possible foils to be processed. Extremely fine features can be cut by laser (Figure 2) and a high aspect ratio (narrow cuts in thicker materials) is possible. For example, 18-µm wide slots can be cut in stainless steel of 100 µm in thickness. The combination of laser cutting and a multi-axis precise cutting machine allows complex geometries to be easily processed, the accuracy determined by the quality of the motion system.

Figure 1: Small components with dimensions measured in µm rather than mm can be laser cut from tube or sheet.

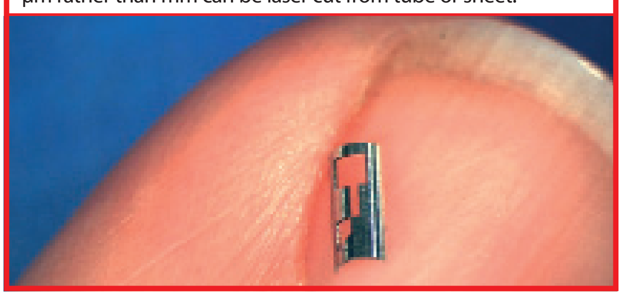
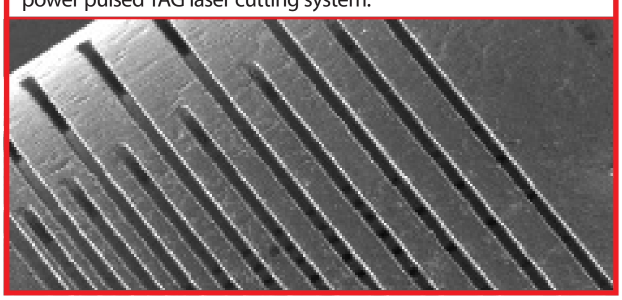


Figure 2: Fine kerf widths (18–40 µm) are achieved with a low power pulsed YAG laser cutting system.



Fine processing of polymers is achieved using lasers of a different wavelength. Using a laser with a short pulse width can minimise the degree of heat affected zone (HAZ), which in turn reduces the amount of cleaning and polishing required after cutting.

Because the laser is suited to automation, it is easily integrated into turnkey systems and can offer a high degree of automatic operation, thus gaining maximum throughput of finished parts with minimum manual intervention. The reliability of automated systems means that unscheduled downtime is rare and in many cases where the laser cutting system is used in a three-shift regime, production time is greater than 98%.

In short, the laser is capable of finer precision than plasma or water jet, which have their own benefits in thicker materials, and the high aspect ratio and speed offer distinct advantages compared with photochemical etching. Laser cutting is typically faster than wire erosion and can also be used in a wider range of materials.

The right laser for the application

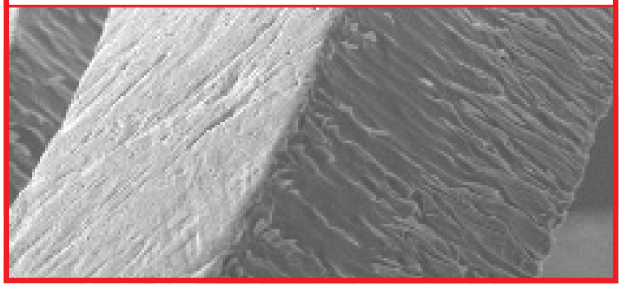
The range of laser types that can be used for micromachining metals and polymers is extensive and choosing the best solution can require a high level of experience and advice. There is no one laser that can be universally applied to all materials and any thickness. Generally, the factors affecting the performance in the material to be cut are:

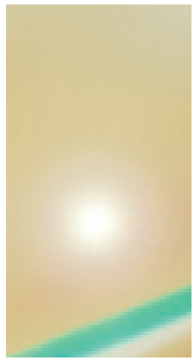
- Peak power density, which depends on pulse energy, duration and spot size
- Coupling efficiency, which depends on wavelength
- Average power, which will determine the process speed.

The lasers used in fine cutting of medical parts are generally one of three main groups:

The ultraviolet laser (wavelength shorter than 300 nm). The Excimer laser (various wavelengths available) and frequency-quadrupled YAG lasers (256 nm) fall into this category. These lasers are not manufactured in high volumes and the power levels generally mean that processing speeds

Figure 3: Edge quality of a laser cut stainless steel stent after cleaning (wall thickness approximately 100 μm).





(material removal rates) are slower than other types. However, the quality that can be obtained is outstanding because the material is ablated rather than vapourised, that is, the material is removed by photochemically breaking down the intermolecular bonds.

The Nd:YAG laser (wavelength 1064 nm). This is in the near-infrared band and is most commonly used in the fine cutting, ablation or drilling of fine metallic components, offering kerf widths down to 18 μm.

The CO_2 laser (wavelength 10.6 μm). This is used in higher powers for sheet-metal profiling, but the theoretical minimum spot size is 10 times larger than the YAG laser. This laser is used for cutting and perforating plastic sheet and other nonmetallic materials.

The capabilities of a YAG laser

YAG lasers are used in cutting medical parts such as stents and other vascular implants manufactured from small-diameter tube. An example of the edge quality on a laser-cut stent is shown in Figure 3. Small components can be made from flat sheet and if a five-axis machine is used, complex three-dimensional shapes can be cut in hemispherical or irregular-shaped parts. The YAG laser is used for drilling fine-holes in the manufacture of filters and surgical instruments and it can cut virtually all metals including those most commonly used in medical devices (stainless steel, platinum, gold and titanium).

New technology in the pipeline

Laser technology is continuously moving forwards and currently much development is taking place in lasers for manufacturing. Diode-pumped YAG lasers offer benefits in terms of improved optical efficiency and reduced maintenance. The laser flash lamp is replaced by a stack of laser diodes, which have longer life and higher efficiency. This should allow higher beam quality, higher power and faster processing with the same or better quality of cut.

Ultra-short pulsed systems are also being developed that can deliver pulses short enough to eliminate any thermal dissipation of the energy into the base material. This improves the quality of the cut and removes the HAZ in some materials by ablation rather than vapourisation of the material, which is removed.

The Femtosecond laser (a femtosecond is one millionth of a nanosecond) is available on the market, although to date cost prohibits its use in many manufacturing applications because material removal is slow and capital is high. It can be predicted that the number of lasers used worldwide for micromachining medical devices will grow dramatically in the next five years. mdt

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