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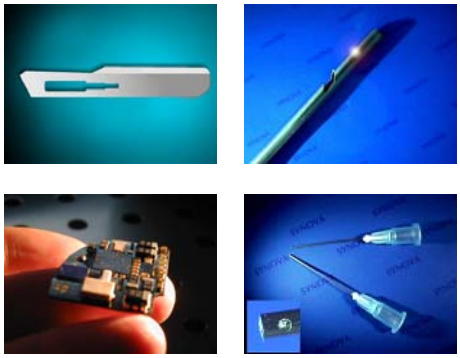
Application Note No. 115

Damage-Free Cutting of Medical Devices with SYNOVA Laser-Microjet®

Medical devices and in particular the stents[1], blades, tubes, and electronic components necessitate high quality manufacturing. Conventional methods have showed their limits in terms of quality and capabilities. The Synova water jet guided laser allows better cutting processes and eliminates **thermal issues** for good.

Description of Products



Blades or scalpels are mainly used in surgical operations; they are also used by dentists, veterinary surgeons as well as by professionals in some other industries. A large amount of blades are produced for different applications. Blades are frequently made of steel, carbon steel, tungsten carbide, ceramics or silicon. The main manufacturing tasks are: cutting out of slots, cutting of complex shapes, edging, drilling and grinding.

Tubes include a large array of devices such as cannulae, needles, or endoscopes. They are usually used for intra vascular operations so they tend to be less traumatic and more minimally invasive. Tubes are normally made of steel, stainless steel, titanium, or nitinol (NiTi). The main manufacturing tasks are:
cutting out of slots, complex cutting, micro drilling of holes, edging. Tube wall thickness usually varies from 30 microns to 600 microns.

Microchips are integrated in sensors, transducers, pacemakers, auditory devices, or flex circuits. They use chips that have to be manufactured (e.g. wafer dicing, singulation). Wafers are typically made of silicon and their thickness vary from 20 to 1500 microns. The main manufacturing tasks are: wafer processing includes a large array of applications such as slicing, dicing, cutting edges, grinding, slotting and drilling.

Description of Conventional Manufacturing Process (State of the Art) and Problem

The most common cutting methods are: conventional laser (Nd:YAG); Electro Discharge Machining (EDM); Electro Chemical Machining (ECM); water jet; grinding wheel; and diamond saw.

Conventional laser is largely used in the medical industry and allows the manufacturing of a large number of materials, devices and applications. However, this method induces several problems such as thermal damages, need of post-processing, conical kerf shapes, and rough edges.

EDM only applies to conductive materials, the speed is low and micro cracks are sometimes observable on the surface. ECM induces corrosion problems and high hydraulic pressure. The main problems of the water jet cutting are concerned with material stress, use of abrasive, cutting forces, and significant maintenance.

Dicing saws are applied to cut wafers into dies. However, this method only works for rectangular shapes and contains several disadvantages, such as low speed, chipping, crack formation due to mechanical stress, and high running costs because of high blade consumption.

[1] Stents are presented in details in the application note no. 111 *"Cutting Stents with Synova Laser-Microjet®"*

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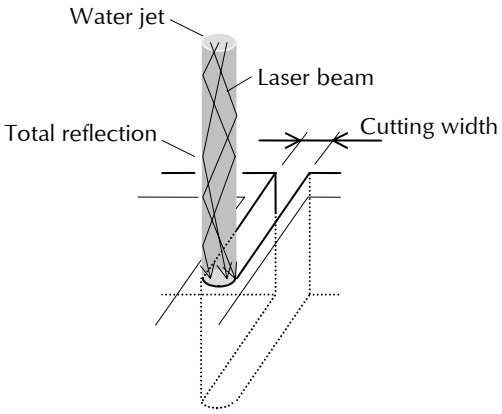
Water Jet Guided Laser Technique

In 1993, scientists at the Institute for Applied Optics at the Swiss Federal Institute of Technology Lausanne succeeded in creating a water jet guided laser, called by its inventors Laser-Microjet®.
The laser beam is focused in a nozzle while passing through a pressurized water chamber. The geometry of the chamber and nozzle are decisive to coupling the energy-rich laser beam in the water jet.
The low-pressure water jet emitted from the nozzle guides the laser beam by means of total reflection at the transition zone between water and air, in a manner similar to conventional glass fibres. The water jet can thus be referred to as a fluid optical wave-guide of variable length.



Cutting with water jet guided laser

Because a pulsed laser is used, the continuous water jet is able to immediately re-cool the cut, resulting in only a very slight depth of thermal penetration. The result is a very narrow, parallel, burr-free, clean cut, without any thermal damage.

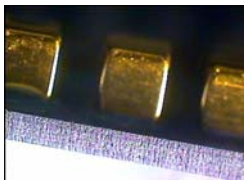
Machining with the Laser-Microjet® Process

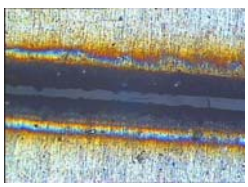
The Laser-Microjet® is well adapted to medical devices; it can cut, drill, groove, mark, scribe or dice with a high degree of precision, speed, cleanliness and reliability. **The problems related to heat damage, post-treatment, debris, deposition, or focal point are totally removed.**

This stainless steel tube was cut with an 80 µm nozzle and a low-pressure water jet. The cutting is very clean and no thermal damages are observable. Needles can be drilled with the same level of quality.

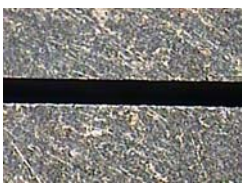
A short-pulse laser and a 50 µm nozzle were used to cut this stainless steel blade. The cutting is excellent and no oxidation or heat affected zone is observable. It is worth mentioning that quality cutting is not reached at the expense of speed.

This cutting of a special shape in silicon was performed with a 50 µm nozzle at a speed of 60 mm/s. Medical electronic devices are perfectly cut without any burrs.




Heat damages caused by conventional laser (100x)

Conventional lasers induce several problems such as heat damages, necessary post-processing, conical kerf shapes, and rough edges. The Synova laser is a "cold laser" allowing excellent cutting quality (parallelism and smoothness) due to the absence of thermal damage.


Perfect cutting with the water jet guide laser (100x)

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Benefits for the Customer

The customer obtains the following advantages:

- High cutting speed
- Excellent tolerances and surface finish
- No thermal damage or material changes
- No burrs, very smooth surface
- No deposition
- Narrow and parallel cuts (28 to 60 µm)
- Significantly reduced post-processing
- No mechanical stress
- Very low running costs, no tool wear
- Constant results
- Any cutting geometry is possible
- New applications
- Higher productivity / better return on investment

Consequence of the Benefits

Because of the significant improvement in quality, productivity and biocompatibility compared to conventional YAG laser process and saws, the Laser-Microjet® process will be the future choice for medical devices manufacturing.

Machine for Laser-Microjet®[2] Cutting of Medical Devices

Synova offers a state-of-the-art, clean-room compatible machine, especially adapted for the cutting of medical devices. Optimum cutting parameters are preloaded. The machine designation is LCS 300.

The machine has a precision of +/- 3 microns, a processing area of 300 X 300 mm and a maximum axis velocity of 1000 mm/s. The system is equipped with CCD camera and fast image treatment software, allowing automatic alignment and inspection. The operation interface is a 15-inch flat colour screen with touch panel, the machine software is based on Windows NT®[3].

The machine can be connected to LAN network for data transmission. The integrated modem allows telediagnostic service. Adapted CAM software can convert all DXF data, fast and easy without special knowledge.

Laser Cutting System LCS 300

A complete list of options is available such as a chiller, alternative laser sources, a water treatment system, 2D-reference scales, and transformers.

The CE and S2 certified Synova machines are field proven and used for 24h production.

[2] Laser-Microjet® is an international protected trademark of Synova S.A., Switzerland.
[3] Windows NT® is a trademark of Microsoft Corp., USA.

