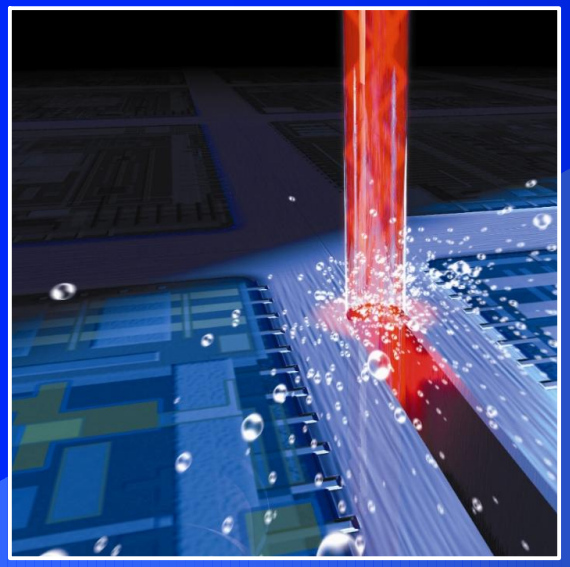
Hannover Messe - MicroTechnology '08
Forum "Innovations for Industry"
April 21-25, 2008

# Recent Applications in Precision Machining with the Laser MicroJet® Technology



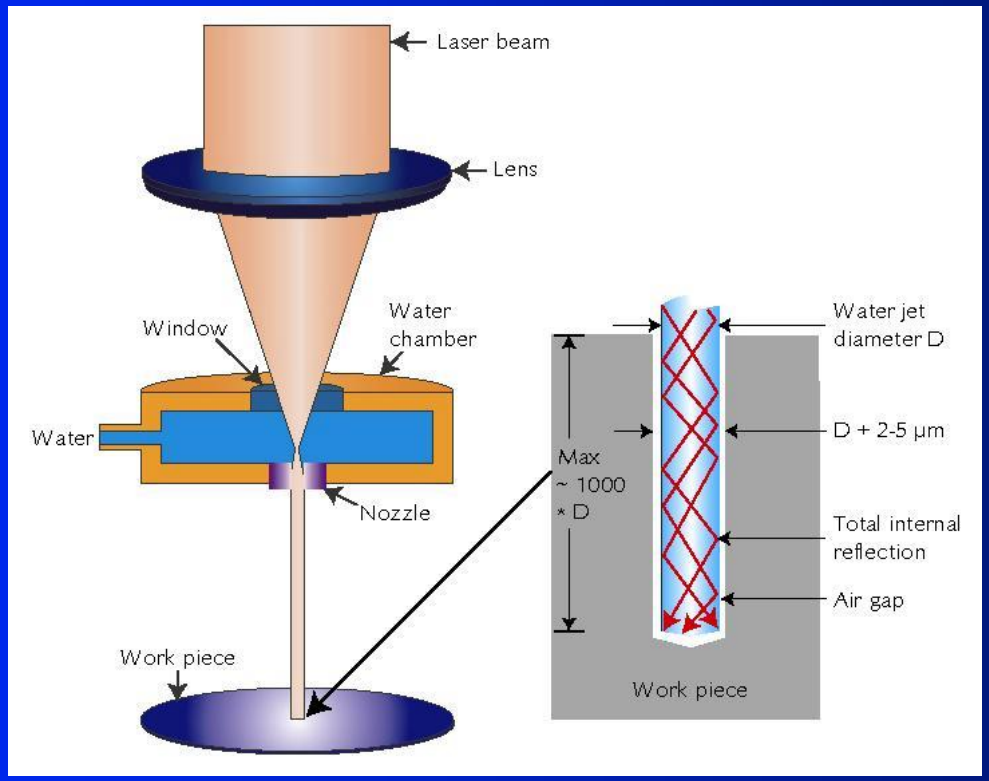
Roy Housh
Arnaud Brulé
Bernold Richerzhagen

**Synova SA, Ecublens, Switzerland**

# Synova Background

| | |
|---|---|
| **Founded:** | 1997 |
| **Headquarter:** | Ecublens/Lausanne, Switzerland |
| **Business markets:** | Semiconductor, solar, electronics, FPD, tooling and industrial micro-machining industries |
| **Technology IP:** | Laser MicroJet® – a water jet-guided laser technology |
| **Applications:** | Micro-cutting, dicing, scribing, edge grinding, drilling, stencil slotting |
| **Employees:** | +70, a majority of which are physicists, micro-technical and electrical engineers |

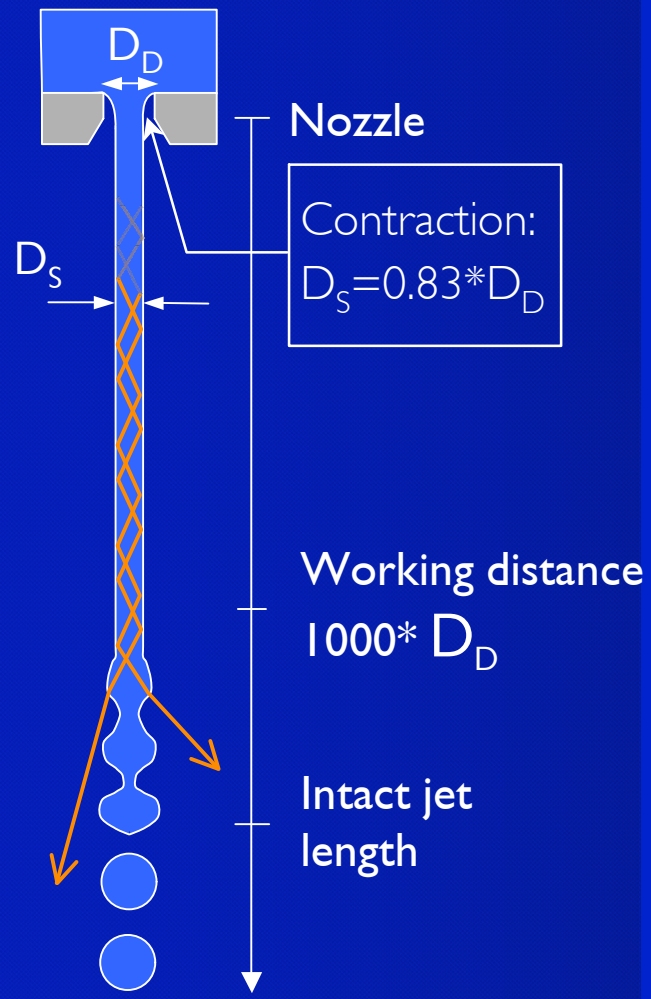
# Water Jet-Guided Laser Principle

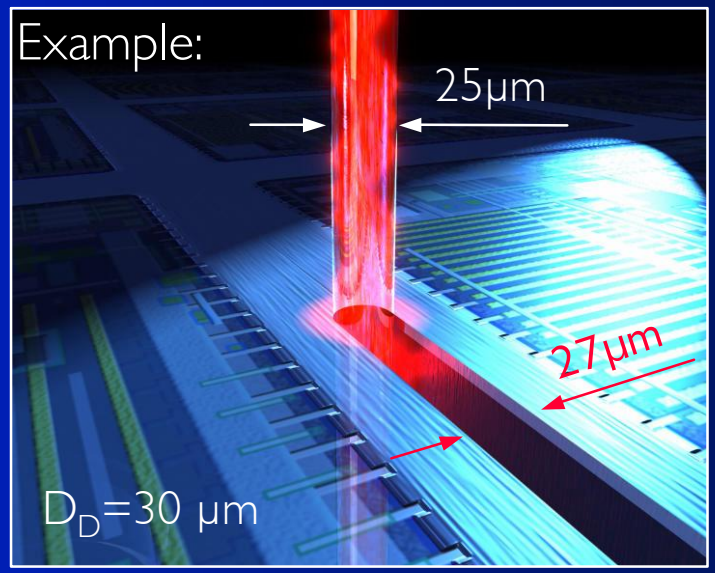



Patented Laser MicroJet® - LMJ

Nozzle w/ diameters 25 - 150µm
Coupling unit consisting of quartz window, chamber & nozzle holder.

# Laser MicroJet® Technology




- Beam guided by total internal reflection to work piece
- Long working distance (>200 mm with large nozzles)

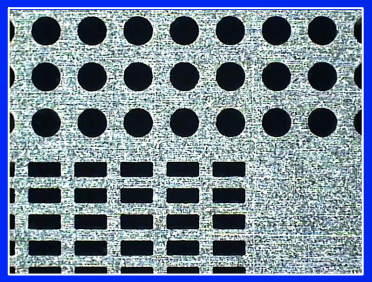
# Advantages vs Dry Laser

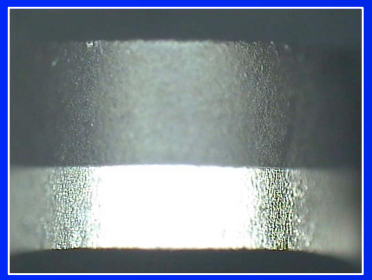
Water jet-guided laser is innovative micro-machining technology, used in various industries. This unique process based on water-guiding laser beam is fundamentally different from conventional dry laser cutting.

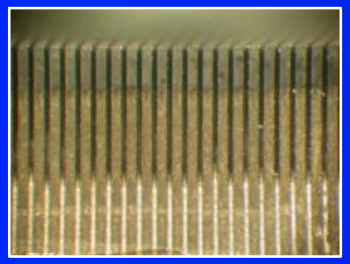
| | Conventional Dry Laser | Water Jet Guided Laser |
|---|---|---|
| **Beam shape** | Conical beam and V-shape kerfs | Parallel beam* and kerf walls |
| **Heating effects** | Heat-affected zone | Negligible heating thanks to water cooling |
| **Material removal** | Inefficient with gas | Molten material washed away by water |
| **Contamination** | Particles attaching to the surface | Thin water film prevents contamination |

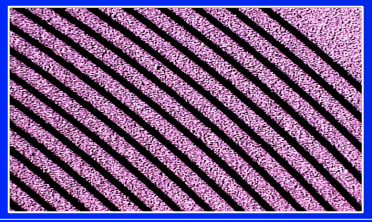
* Additional related advantages: No focusing requirements, long working distance, high aspect ratio

# Range of Industrial Markets

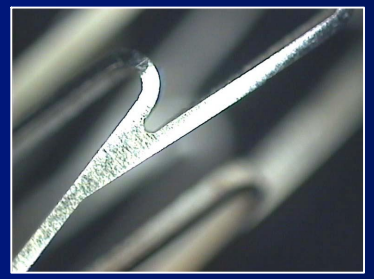


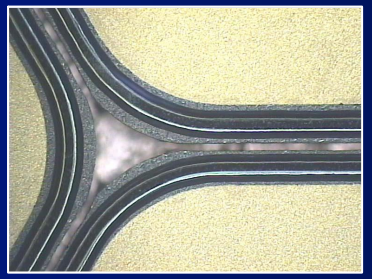






- Semiconductors, IC wafers (Si, GaAs, GaN, InP, Low-k, SiC)
- Solar cells (mainly crystalline Silicon)
- Metal masks (stencils, OLED screens)
- Electronics (inkjet printer heads, hard disk drive heads, ferrite cores, ceramic substrates)
- LED
- Hard materials (PCD, CBN, etc.)
- Automobile (injection nozzles, etc)
- Medical devices (stents, blades, PZT)
- Watch parts





# Selected Precision Applications

The precision applications presented here encompass the following industries:

- Semiconductor : cutting of thick silicon wafer, cutting optical elements from pure silicon wafer and edge chamfering of thick silicon wafer
- Watch making : cutting of watch hands from steel or brass sheet material
- Medical devices: cutting of stents and tubing for endoscopy
- Machine tooling: cutting hard materials such as PCD/WC and CBN/WC

# Improving Processing Results

The materials used in these applications each pose their own problems when trying to cut them with conventional lasers, even ultra short pulse UV ones, due notably to:

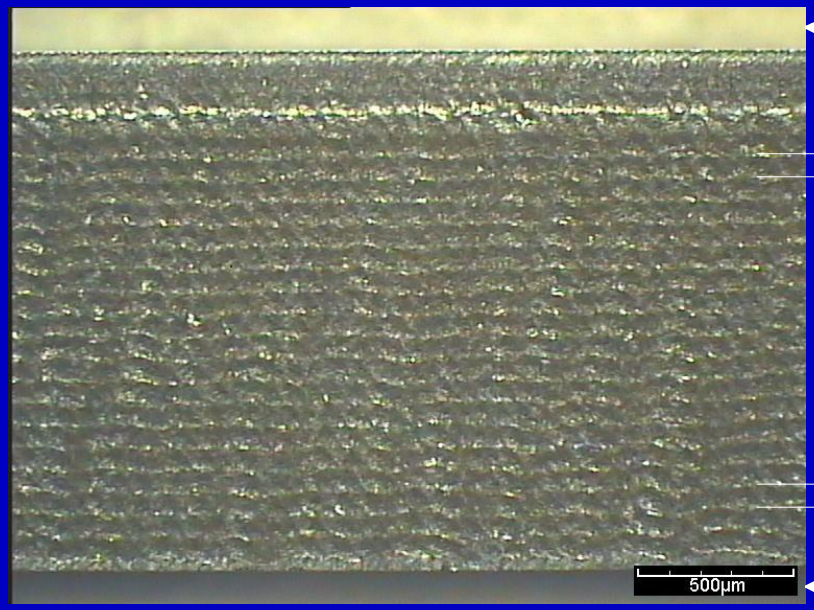
- low ablation rates
- higher post-processing time and cost

The Laser MicroJet® has demonstrated superior results in terms of it's:

- speed
- precision cutting, with perfectly parallel kerf walls
- cutting and drilling both thin and thick materials
- minimal HAZ and back surface chipping
- flexibility

The water jet simultaneously provides a highly effective cooling and cleaning mechanism, eliminating any post cutting processes required by other cutting techniques.

# Semiconductor Applications (1)



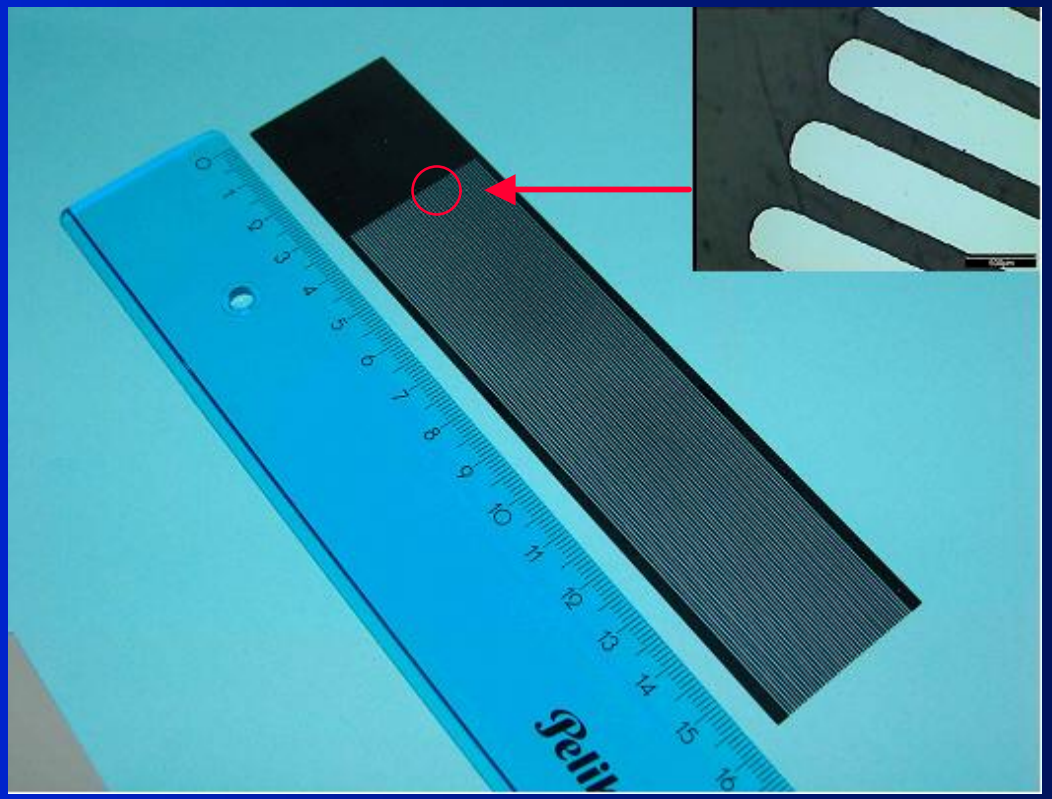

| | | |
|---|---|---|
| Pulse Freq. | 22 | KHz |
| P average | 31 | W |
| LMJ nozzle | 50 | µm |
| Water Pres. | 200 | Bar |

This 1770µm thick sample of silicon wafer was cut with a pulsed diode pumped 532nm Nd:YAG laser, in a total of 28 passes, giving an overall cutting speed of 257mm/min.

The ripple visible in the image of the side wall amounts to <2 µm.

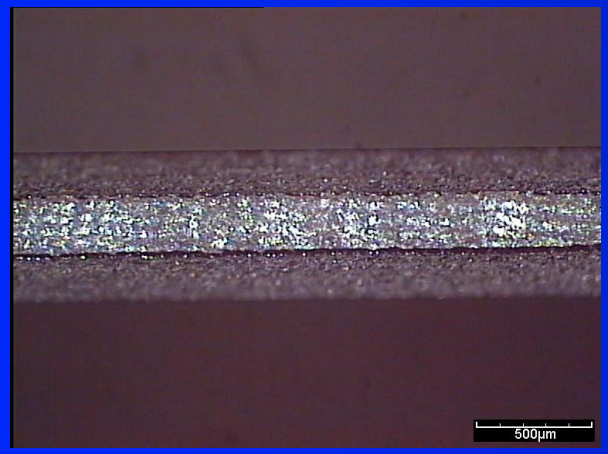
# Semiconductor Applications (2)

| | | |
|---|---|---|
| Pulse Freq. | 40 | KHz |
| P average | 32 | W |
| LMJ nozzle | 50 | µm |
| Water Pres. | 150 | Bar |

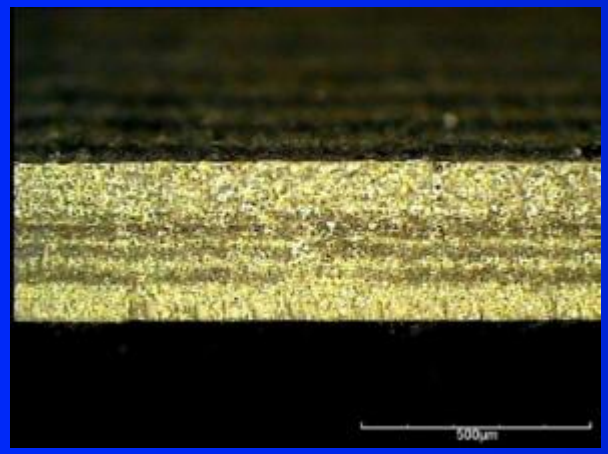


The "comb" like structure was cut from Ø300mm 250µm thick pure silicon wafer with a pulsed diode pumped 532nm Nd:YAG laser. Each of the 40 cuts, 400µm wide by 125mm long were made in 4 passes, at a cutting speed of 100mm/s. The inset shows the back surface of the "comb" tips after separation.

# Semiconductor Applications (3)



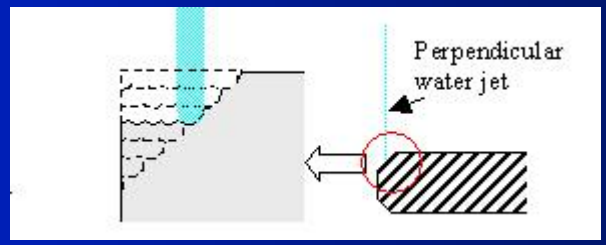

Side wall cut with chamfers




Chamfer surface

| | | |
|---|---|---|
| Pulse Freq. | 15 | KHz |
| P average | 7-10 | W |
| LMJ nozzle | 50 | µm |
| Water Pres. | 180 | Bar |

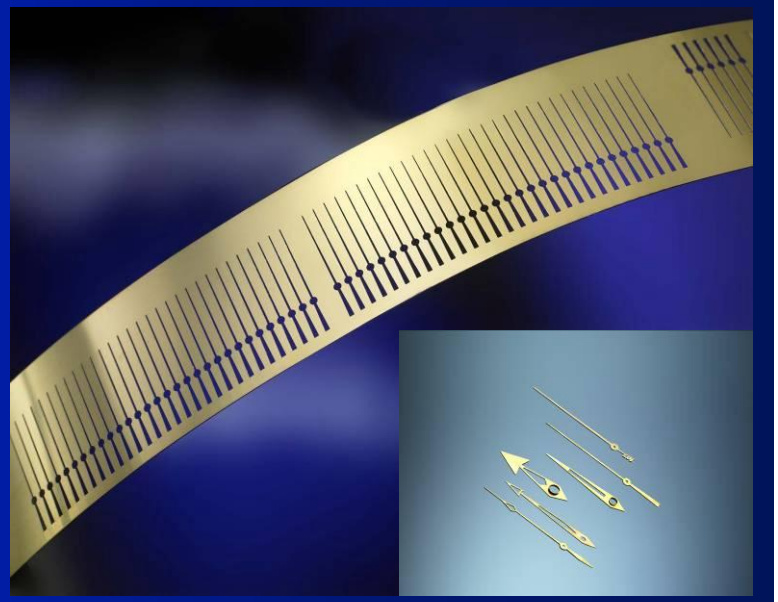
In this application different width 45° chamfers were cut on each side of 700µm thick silicon wafer as shown below, with a pulsed diode pumped 532nm Nd:YAG laser.




| Nr. passes/side | Chamfer width [µm] | Chamfer height [µm] | Total Process time [s] |
|---|---|---|---|
| 15 | 130-135 | 135 | 189 |
| 66 | 340 | 380 | 829 |
| 36 | 250-275 | 260 | 452 |

# Watch Applications


Magnified views of watch hands directly after cutting



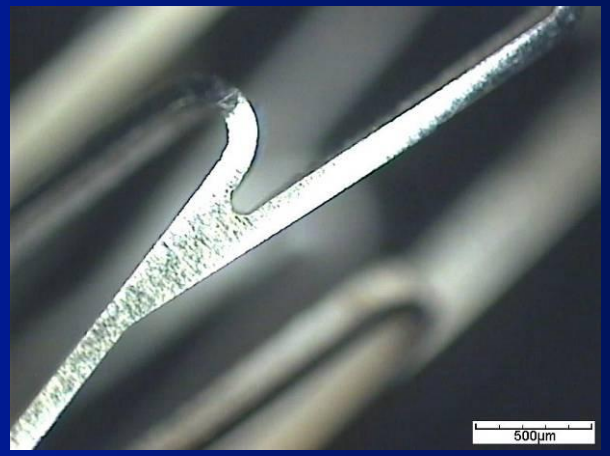
This application demonstrates the LMJ's ability to cut very fine parts from 200µm brass sheet. A diode pumped 532nm Nd:YAG laser was used. Each hand was cut in 5 passes from the sheet in <8seconds in a continuous operation. The inset image shows several different finished parts.

| | | |
|---|---|---|
| Pulse Freq. | 15 | KHz |
| P average | 40 | W |
| LMJ nozzle | 40 | µm |
| Water Pres. | 280 | Bar |

# Medical Applications (1)

Cutting of high quality stents for the medical industry is a very demanding application. The magnified image at right shows a 200µm thick Nitinol part, cut using a diode pumped 1064nm IR laser, directly after cutting at 9mm/s.
No HAZ, burrs or particle contamination is present.

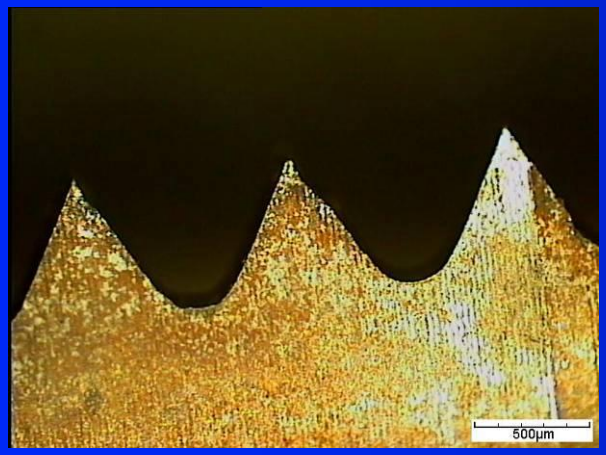
| | | |
|---|---|---|
| Pulse Freq. | 1.5 | KHz |
| P average | 23 | W |
| LMJ nozzle | 30 | µm |
| Water Pres. | 300 | Bar |



Stent directly after cutting


Examples of different stents

# Medical Applications (2)




| | | |
|---|---|---|
| Pulse Freq. | 25 | KHz |
| P average | 60 | W |
| LMJ nozzle | 50 | µm |
| Water Pres. | 400 | Bar |

A further very demanding application for the medical industry is manufacturing devices for endoscopy. The magnified image at left shows a device cut from Ø5.2mm stainless steel tubing, wall thickness 350µm, using a diode pumped 532nm laser, directly after cutting at 25mm/s.

No HAZ, burrs or particle contamination is present.

Processing time for the complete part was ~140 seconds.

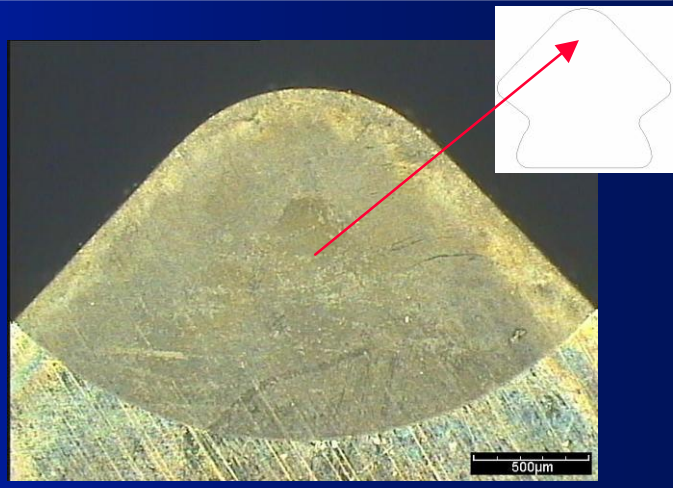
**Note**:-
Discolouring of material in the above image was already present, and is not as a result of cutting with the LMJ.

# Tooling Applications (1)

Cutting complex layered tooling inserts for the machine tool industry is a further very demanding application.
This example shows the CBN tip insert in a WC backing material. This was cut in a "Christmas tree" shape from a 5mm thick disk, using a pulsed dual cavity Q-switched 532nm laser.

Cutting speed was 10mm/s with 220 passes.

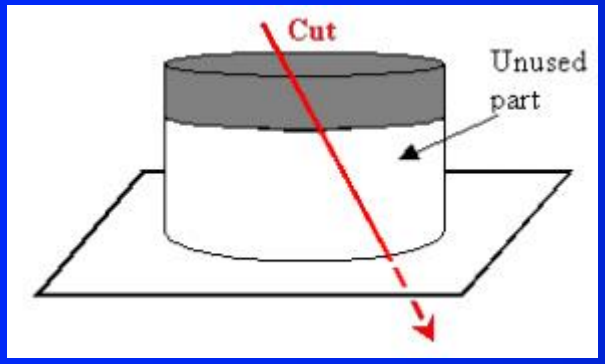
Resulting quality is as good as using Electrical Discharge Machining (EDM), but LMJ is 10x faster.



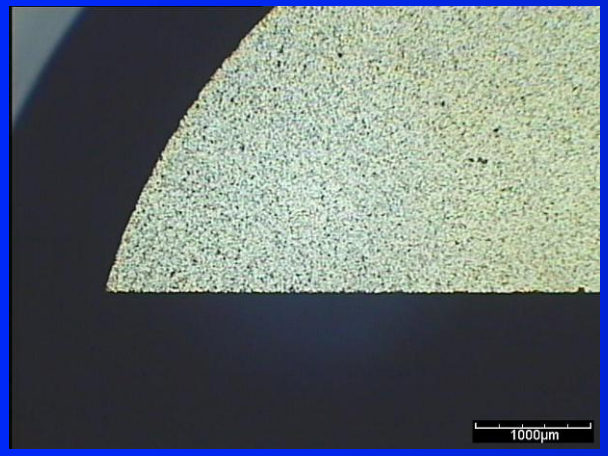

Microscopic top view of front side of insert tip

| | | |
|---|---|---|
| Pulse Freq. | 8 | KHz |
| P average | 140 | W |
| LMJ nozzle | 80 | µm |
| Water Pres. | 400 | Bar |

# Tooling Applications (2)




Sketch of cutting requirements




Microscopic view of topside of CBN tip

This second application for machine tooling involved making a chamfered cut through a Ø13.4mm cylinder composed of ~1.5mm CBN layer on a ~6.5mm WC backing, using a pulsed dual cavity Q-switched 532nm laser.
Cutting speed was 20mm/s requiring 700 passes.

| | | |
|---|---|---|
| Pulse Freq. | 8 | KHz |
| P average | 140 | W |
| LMJ nozzle | 80 | µm |
| Water Pres. | 400 | Bar |

# Technology Benefits + Modularity

**Laser MicroJet® cutting**

- High speed
- High precision - 3 to 5 µm
- Low manufacturing costs
- No burrs, no particles
- Negligible thermal and mechanical stress
- Flexibility
- Environmentally friendly
- Available now

**Laser Systems**


**Cutting**


**Dicing**


**Stencil**

LMJ process integrated in the system meeting at best manufacturing specific needs

# The Laser MicroJet®

**Thank you for your attention.**

info@synova.ch