

Laser MicroJet® Technology

 **SYNOVA**

Cool Laser Machining

www.synova.ch





Synova S.A., headquartered in Duillier, Switzerland, manufactures leading-edge laser cutting systems since 1997 that incorporate the proprietary water jet guided laser technology (Laser MicroJet®) in a true industrial CNC platform. Customers benefit from significant yield and quality improvements in cutting, as well as enhanced capabilities for micro-machining a wide range of materials. Synova is a privately owned company with subsidiaries in North America and the Asia/Pacific region.

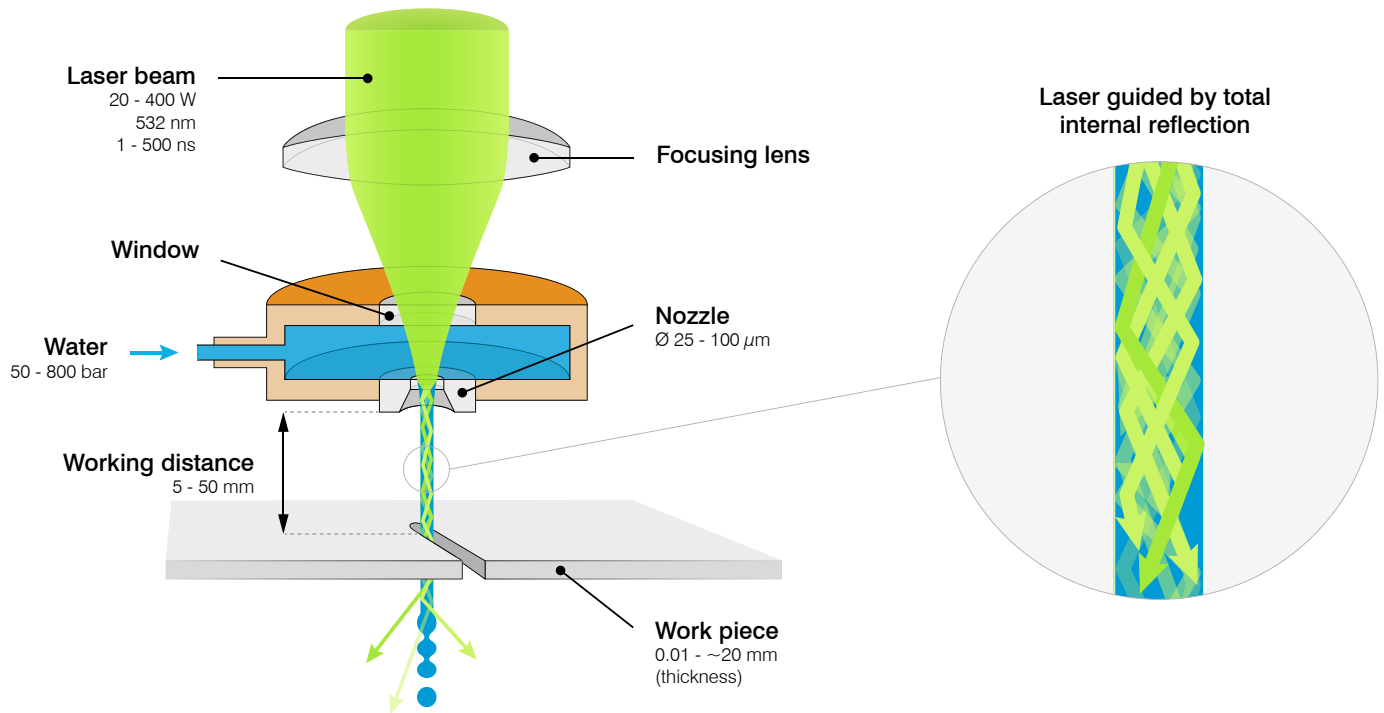


The Laser MicroJet® Technology

A SIMPLE PRINCIPLE

The Laser MicroJet (LMJ) is a hybrid method of machining, which combines a laser with a “hair-thin” water jet that precisely guides the laser beam by means of total internal reflection in a manner similar to conventional optical fibers. The water jet continually cools the cutting zone and efficiently removes debris.

As a “cold, clean and controlled laser”, Synova's LMJ technology resolves the significant problems associated with dry lasers such as thermal damage, contamination, deformation, debris deposition, oxidation, micro-cracks, lack of accuracy and taper.



Technical Parameters

Lasers

- Diode-pumped solid-state pulsed Nd:YAG lasers with pulse durations in the micro- or nano-second range, operating at 1064, 532 or 355 nm
- Average laser power ranges from 20 to 400 W

Water

- Pure deionised and filtered water
- Water consumption is low due to “hair-thin” jet: approx. 10 litre/hour at 50-800 bar pressure
- Resulting forces exerted are negligible ($< 0.1 \text{ N}$)

Nozzles

- Nozzles made of sapphire or diamond, as these materials' hardness enables the generation of a long, stable water jet over a long period of time without requiring replacement
- Diameter range: $25 - 100 \mu\text{m}$

The Fusion of Water and Light

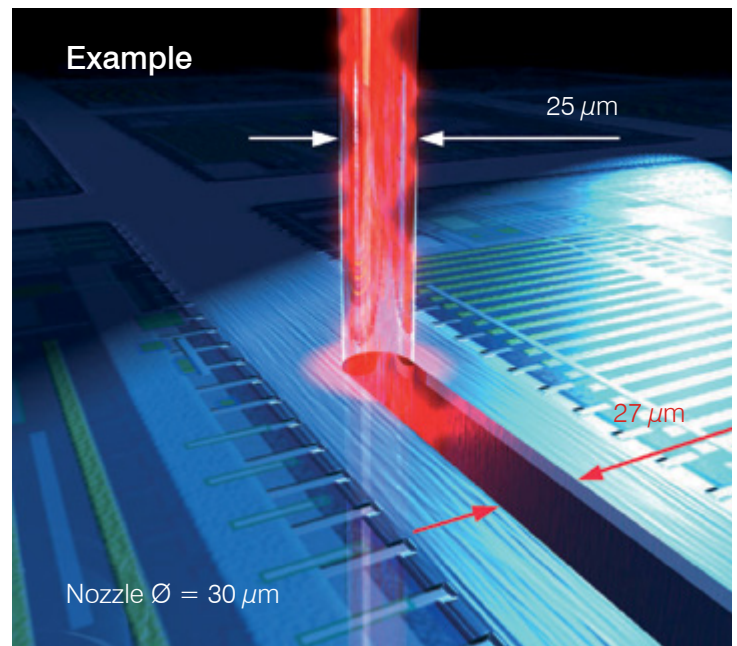
HIGH-PRECISION MICRO-MACHINING

The water jet guided laser is a revolutionary cutting technology, which combines the low-temperature and large working distance advantages of water jet cutting with the precision and speed of conventional dry laser cutting.

As a result, the Laser MicroJet has a remarkably wide range of applications and has established itself amongst other well-known cutting methods including dry lasers, diamond saws, EDM, stamping, water jet cutting and etching.

The LMJ technology is particularly valuable for very thin kerf cutting, delicate surface coatings and high-precision processing of thin work pieces sensitive to deformation and heat as needed in the semiconductor industry, for instance.

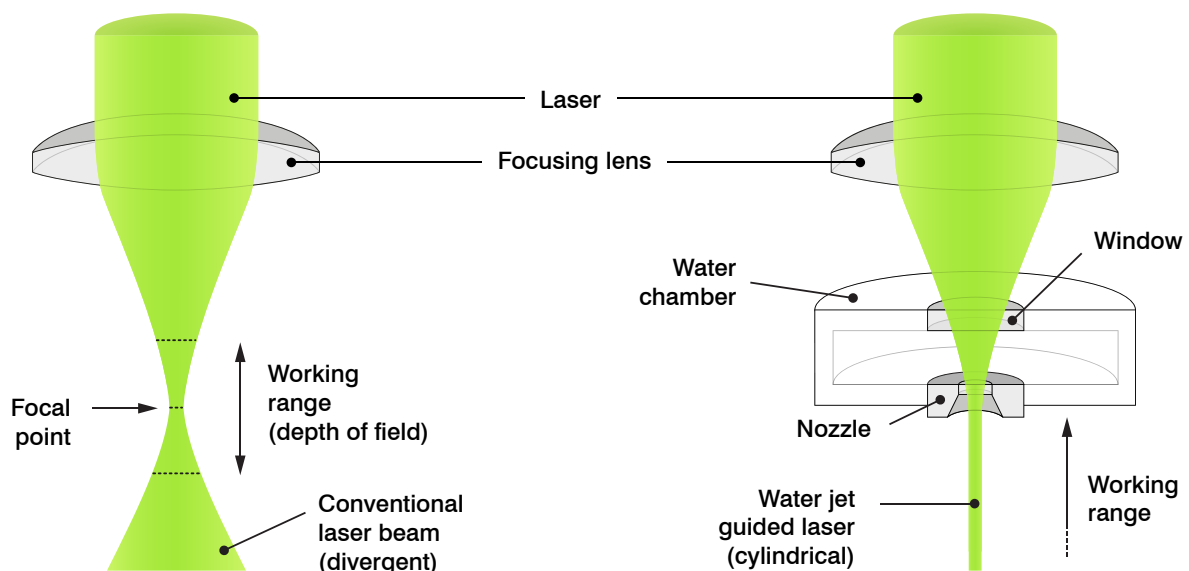
Finally, the cylindrically guided laser is ideal for the parallel cutting of super hard materials and rough diamonds with minimal material loss.



The cutting kerf width ranges from 27 to 100 μm , depending on the nozzle size. The laser energy is always guided to the bottom of the kerf.

The Perfect Shape

COMPARISON OF CONVENTIONAL AND MICROJET LASER BEAMS



The conventional focused laser beam has a limited working distance of just a few millimetres to even fractions of a millimetre due to beam divergence. This not only makes precise focussing and distance control necessary, it also limits the ratio of kerf width to depth.

The Laser MicroJet technology employs a laser beam that is completely reflected at the air-water interface. The beam can be guided over a distance of up to 10 cm, enabling parallel high aspect ratio kerfs. No focussing or distance control is required.

Technology Benefits

Conventional Laser

Requires precise focus adjustment



Conical laser beam leaves non-parallel kerf walls



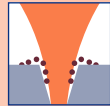
Limitations in cutting aspect ratio



Heat affected zone



Particle deposition



Inefficient material removal leaves burrs



EDM

Only electrically conductive materials



Slow ablation process and time-consuming preparation



Expensive consumables (EDM wire)



Laser MicroJet

No focus adjustment required, non-flat surfaces are not an issue, 3D cutting possible, variable cutting depth of up to several cm



Cylindrical beam results in parallel kerf walls, consistent high quality cutting



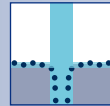
High aspect ratio, very small kerf width ($>20 \mu\text{m}$), minimal material loss, with simultaneous deep cuts possible



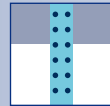
Water-cooling process avoids thermal damage and material change, high fracture strength is maintained



A thin water film eliminates particle deposition and contamination, no surface protection layer required



High kinetic energy of the water jet expels molten material, no burrs form

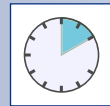


Laser MicroJet

Wide range of materials



Fast machining



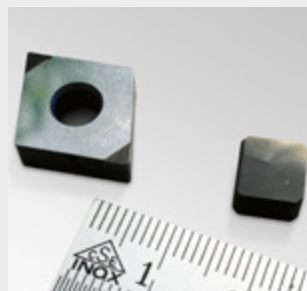
Low running costs (no tool wear, low water consumption and waste rates)



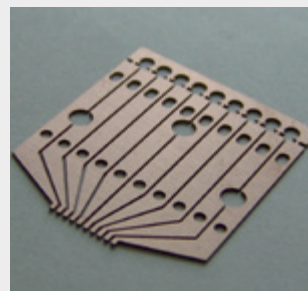
Applications



Energy & Aerospace: Turbine blades. Drilling of 8 mm superalloys: 70 s/hole



Tool Manufacturing: Tool inserts. Cutting of 1.6 mm PCD/WC: 5 mm/min



Micro-Machining: Connector blades. Cutting of CuBe: 0.5 to 2 mm/s



Diamonds: Rough diamonds. Cutting of 5 mm rough diamond in 5 min

Applications and Performance Capabilities

THE STRENGTHS OF THE LASER MICROJET

Materials

The water jet guided method allows the machining of a **broad range of materials**. Since it's a very gentle process, the LMJ is particularly well-suited for machining brittle materials that are easily damaged using traditional cutting processes:

- Diamonds: Rough and synthetic diamonds (CVD, HPHT)
- Metals: Stainless steel, aluminium, Durnico, CuBe, copper, brass, shape-memory alloys (nitinol), titanium, nickel, superalloys
- Hard materials: Polycrystalline CBN (PcBN), polycrystalline diamonds (PCD), monocrystalline diamonds (MCD)
- Ceramics: Zirconia (ZrO_2), low-temperature co-fired ceramic (LTCC), aluminium nitride (AlN), aluminium oxide (Al_2O_3)
- Semiconductors: Silicon (Si), gallium arsenide (GaAs), silicon carbide (SiC)
- Ceramic-matrix composites (CMCs)

Operations

Thanks to its versatile technology, the LMJ can be used for a **multitude of processes** including cutting, drilling, edge grinding, grooving, scribing, milling, dicing, shaping in 3 and 5 axes, trenching, profiling, slotting and engraving.

Quality

Thanks to the water jet cooling capability there is virtually **no heat impact**. The ablated material is removed with the water flow leaving **clean surfaces** and less scrap.

Thickness

The LMJ can cut a **wide range of material thicknesses**, e.g. cutting of up to 20 mm thick silicon or drilling of up to 15 mm thick superalloys (hole diameter 800 μm).

Speed

The usage of industrial high-power lasers enables **high cutting speeds**, especially with thin materials: up to 300 mm/s in 50 μm thick silicon, up to 30'000 round holes/hour in 50 μm thick stainless steel (diameter 80 μm).

Accuracy

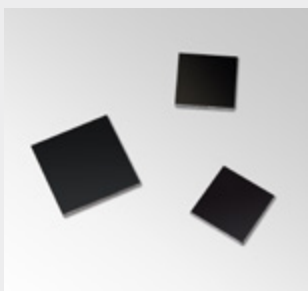
The lasers used in Synova's machines are **ultra-precise** tools which can achieve very small **parallel kerfs** – from 25 to 100 μm – with an absolute precision as low as $\pm 1.5 \mu\text{m}$, resulting in appreciable material savings.

Shapes

LMJ machines allow **omni-directional ablation** processes, making the creation of any shape possible. This provides customers with the flexibility to develop new ideas and applications, from making small wheels for the watchmaking sector to dicing chips of any shapes in the semiconductor industry.

Costs

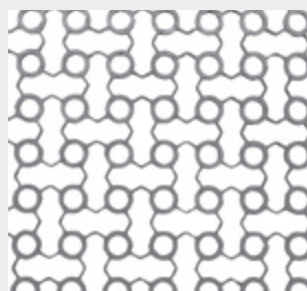
The efficient and precise LMJ technology enables **low running costs**: no tool wear, very few consumables and low waste rates.



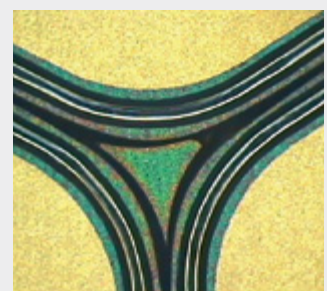
Synthetic Diamond: CVD diamonds. Slicing of 7 mm CVD diamond in 5-6 min



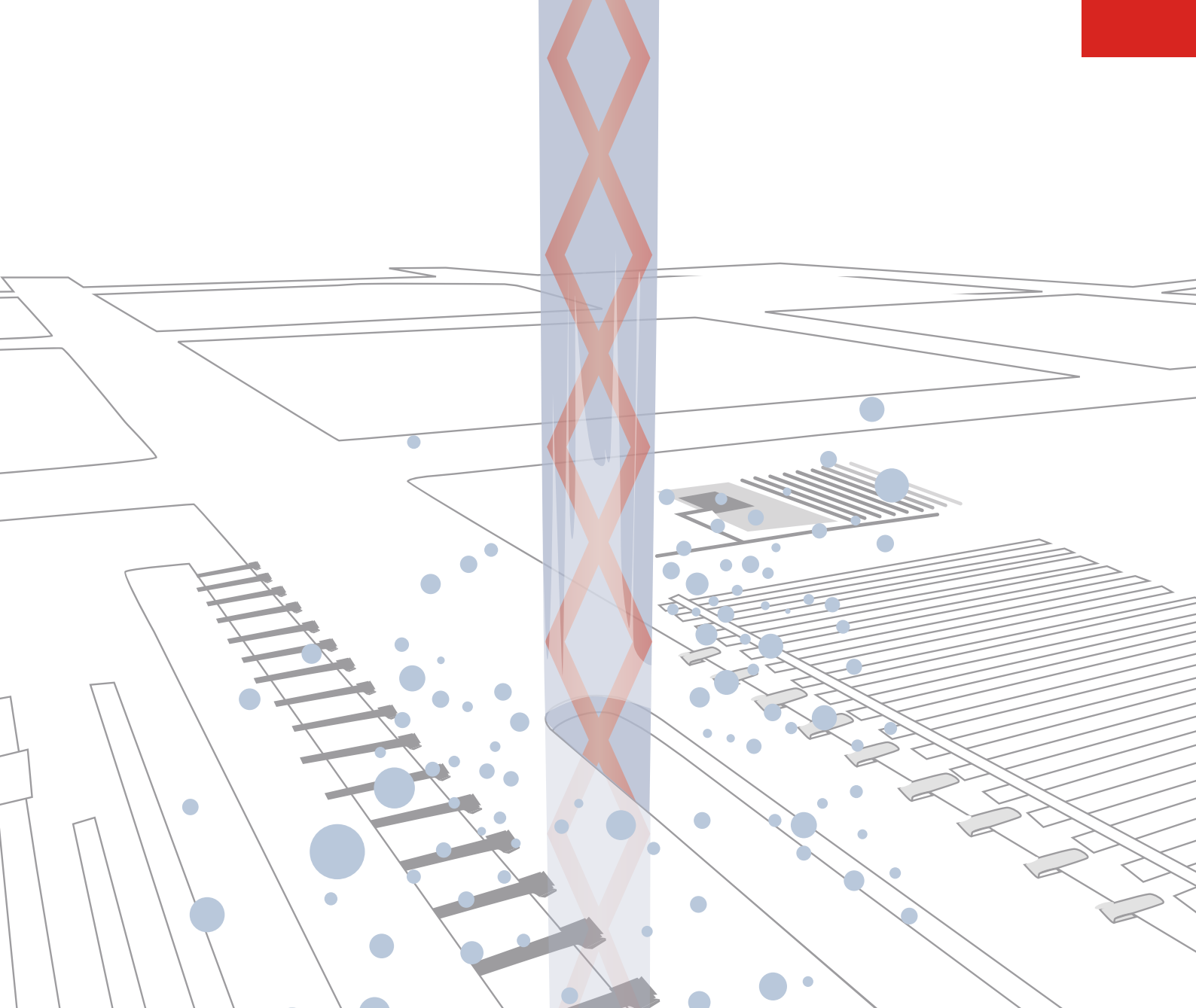
Watchmaking: Escape wheels. Cutting of CuBe: 0.5 to 2 mm/s



Medical: Medical implants. Cutting of titanium: 0.5 mm/s



Semiconductors: Diode chips. Dicing of 50 μm silicon: 300 mm/s



The Fusion of Water and Light



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Contact information available at: www.synova.ch