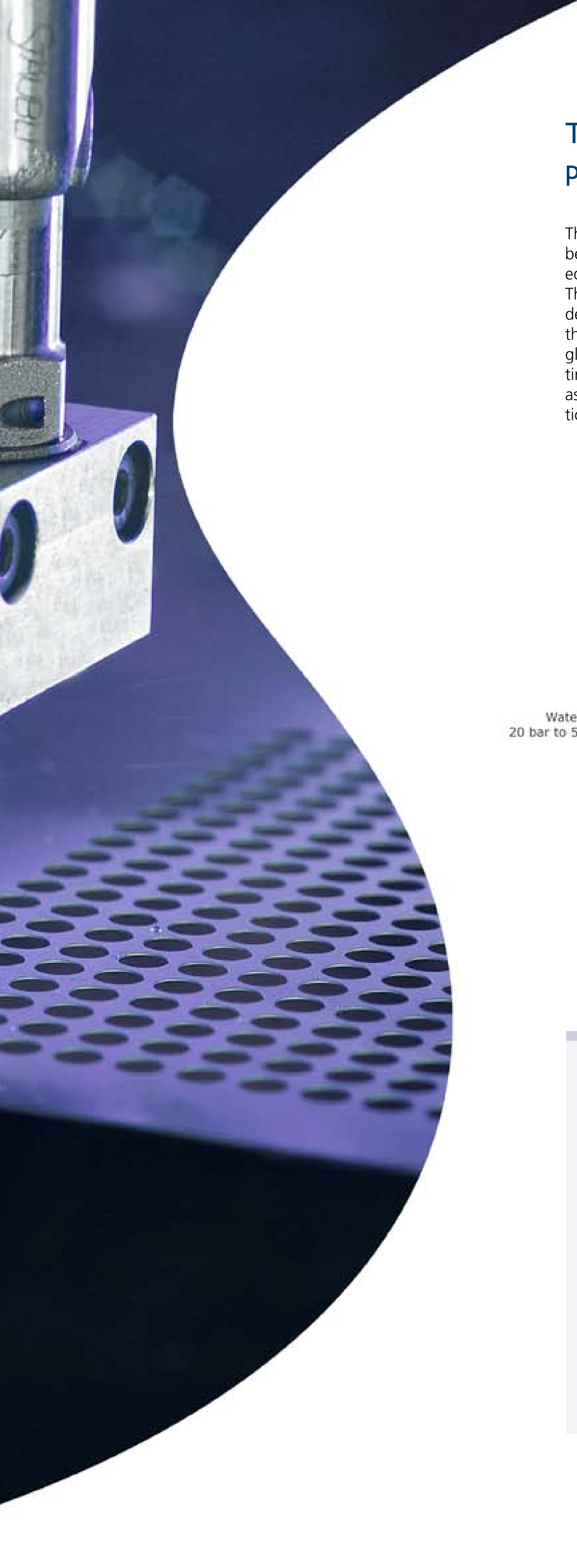
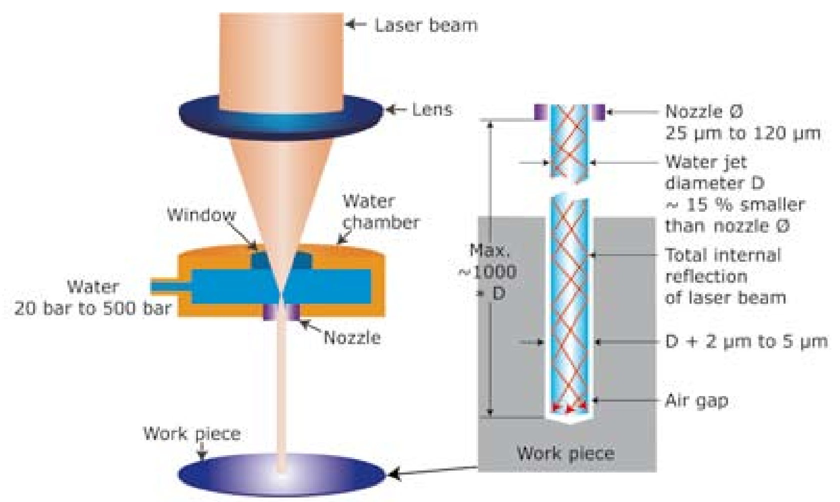
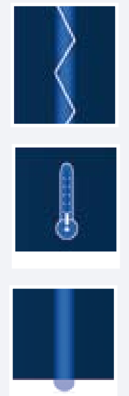


The patented Laser MicroJet® principle

The Laser MicroJet® is a hybrid method combining a laser beam with a low-pressure water jet, which cools the cut edges and provides effective debris removal from the kerf. The low-pressure water jet, emitted from the nozzle, guides the laser beam by means of total internal reflection at the water/air interface, in a manner similar to conventional glass fibres. It is therefore a "cold and clean laser" eliminating all the known problems associated with dry lasers such as thermal damage, contamination, deformation, deposition, oxidation, micro-cracks and lack of accuracy.



How Does Water Help ?



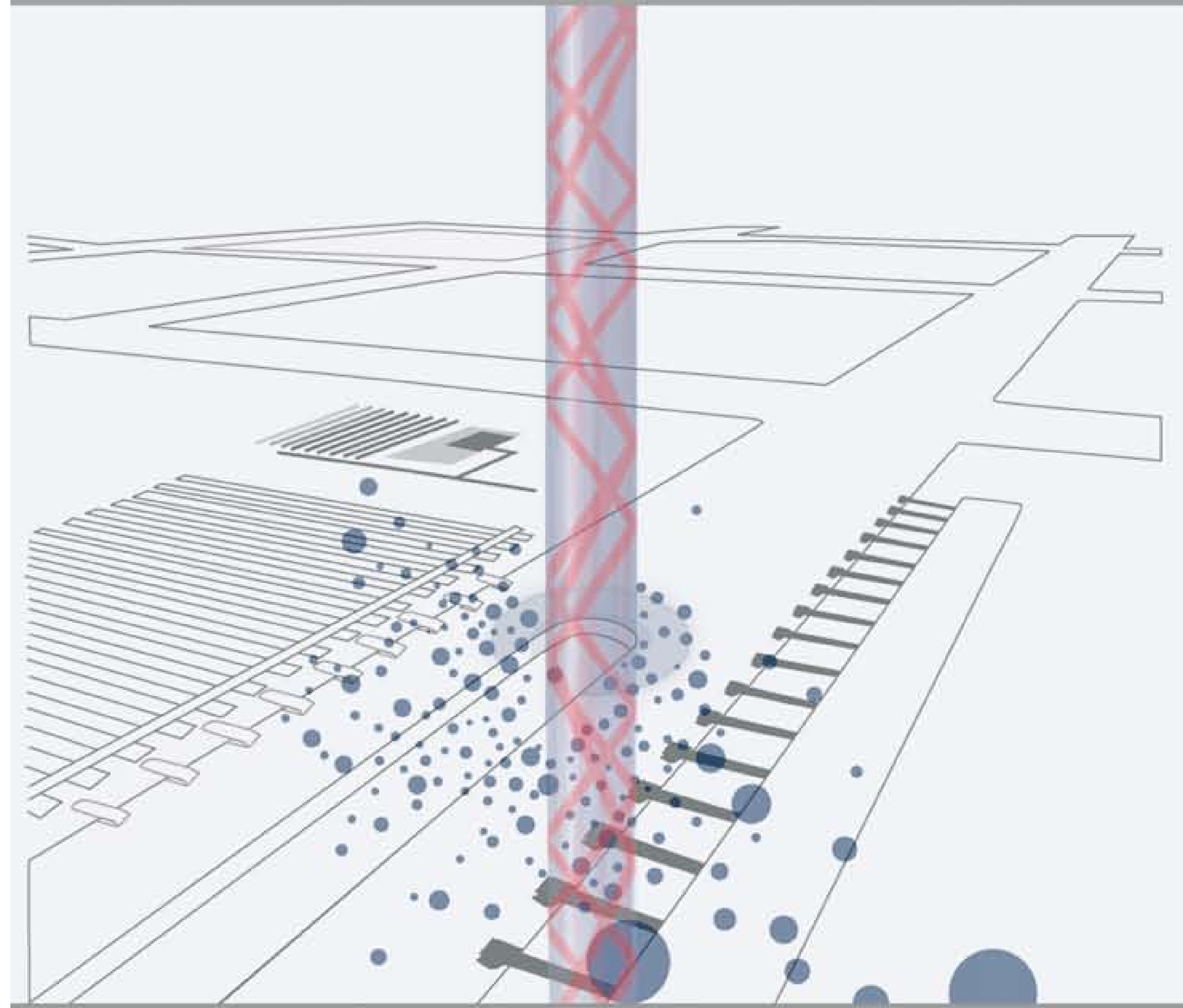
The water jet works as an optical fibre of variable length for guiding the laser beam.

The water jet cools the work piece during laser ablation.

The water jet ejects the molten material.

The water jet alone does not ablate nor affect the material.

The Laser MicroJet® Technology



The Synergy of Water and Fire

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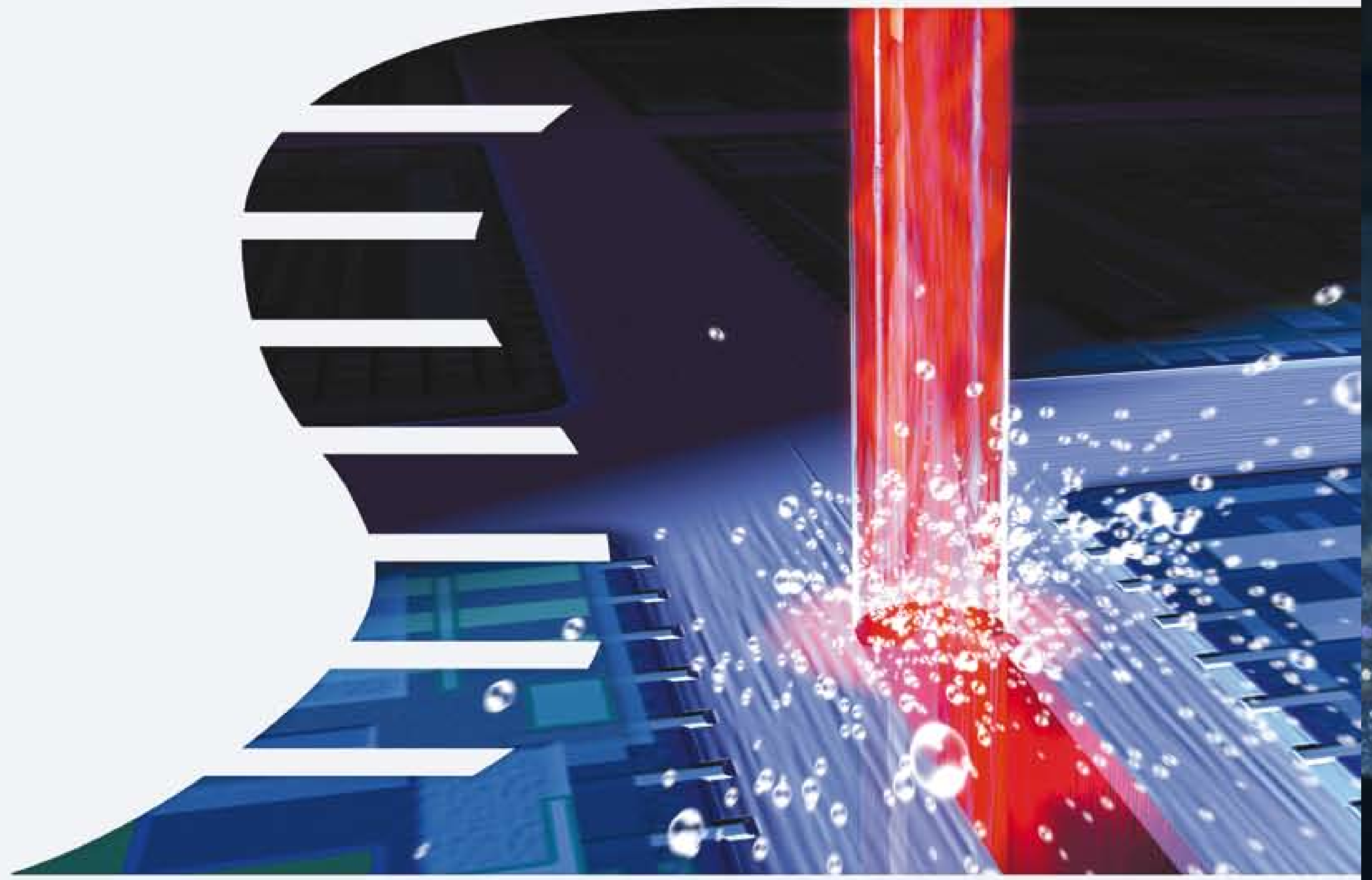
The Laser MicroJet® TECHNOLOGY

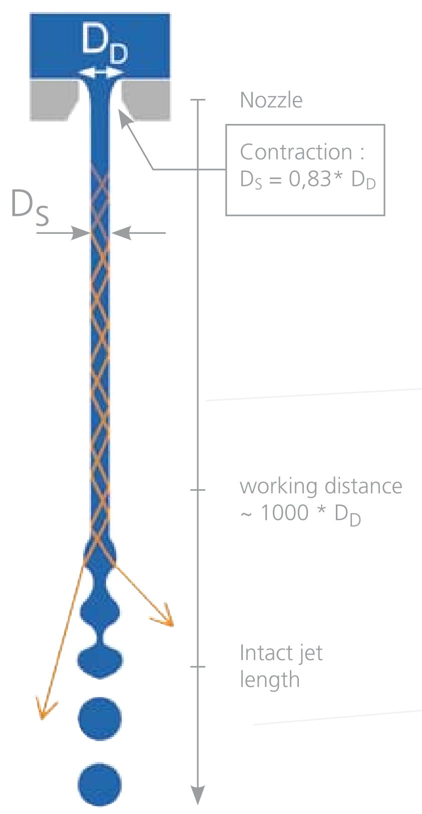


cutting grooving dicing
edge-grinding drilling marking
milling cleaning slotting
scribing isolating structuring

Expand your capabilities with the latest development in Laser Technology

SYNOVA

Laser guidance in a water jet...

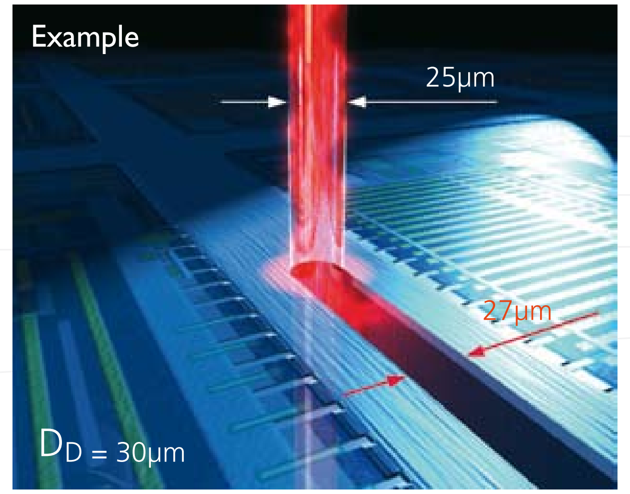


A unique invention

The world's first water jet-guided laser – a groundbreaking technology previously attempted by many scientists without success – was successfully developed in the early nineteen-nineties at the Federal Institute of Technology, Lausanne (Switzerland).

As the sole inventor of Laser MicroJet® (LMJ), Synova maintains all rights to this protected technology. With almost two decades of accumulated expertise in liquid-guided lasers, Synova holds numerous international patents.

...of variable width



• *The cutting kerf width ranges from 27 µm to 100 µm, as a function of the nozzle size.*

• *The laser energy is always guided to the bottom of the kerf.*

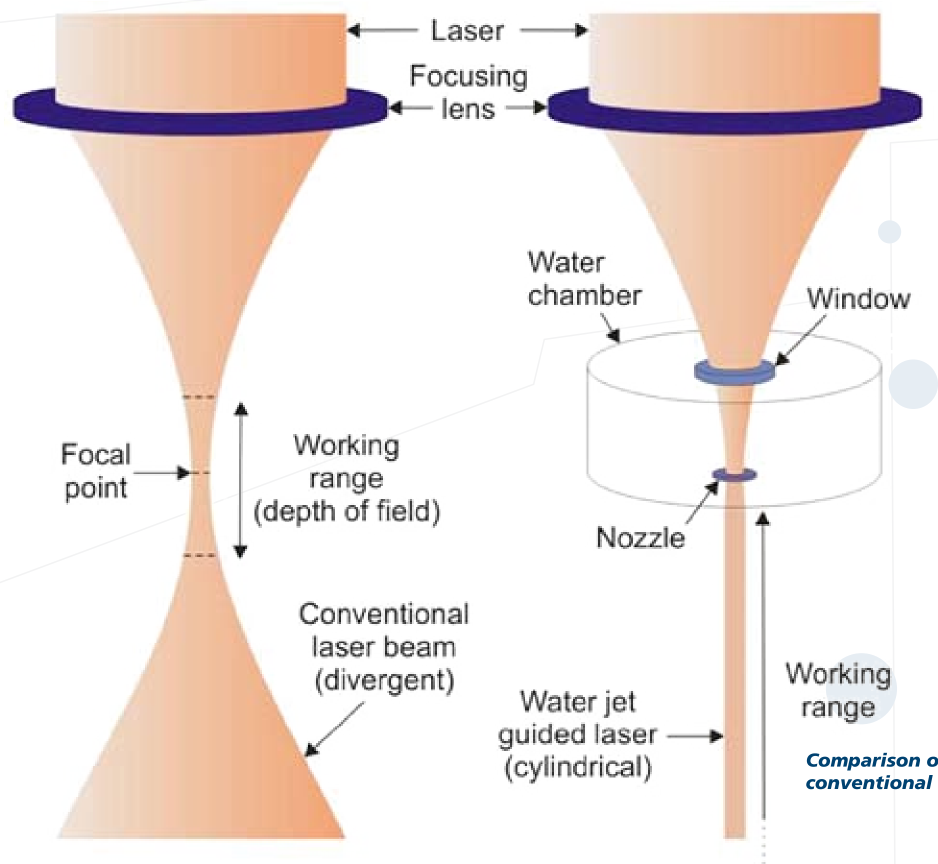
Technical parameters

Lasers	Lasers used are flash lamp or diode pumped solid state pulsed Nd:YAG lasers with pulse durations in the micro- or nano-second range, operating at 1064 nm, 532 nm, or 355 nm. Average laser power ranges from 10 W to 200 W.
Water	Pure deionised and filtered water, at low pressure, are used. Because the jet is "hair thin," the level of water consumption is extremely low—in the order of 1 litre per hour at 300 bar pressure and the resulting forces exerted are negligible (<0.1 N).
Nozzles	The nozzles range in diameter from 25 to 100 µm and are made of sapphire or diamond, as these materials' hardness enables generations of a long, stable water jet over a long period of time without requiring replacement.

A revolution in precision machining

The water jet-guided laser is a revolutionary cutting technology, combining advantages of water jet cutting (cold, large working distance) and of conventional dry laser cutting (precise, fast). As a result, this process is successfully competing with diverse well-known cutting methods, including dry laser, diamond saw, EDM, stamping, water jet cutting and etching.

The benefits of this technology are particularly valuable for very narrow kerf cutting, delicate surface treatments and high-precision processing of thin work pieces sensitive to deformation and heat. The water jet-guided laser is even more suitable when delicate pieces of sensitive materials need a precise, clean and fast processing, as in the semiconductor industry for instance. At the same time, cutting of super hard materials is possible, indicating how extremely wide the range of applications is. Moreover, this modern technology is an environmentally friendly and non-polluting production method.



Comparison of laser beams: conventional vs water jet-guided

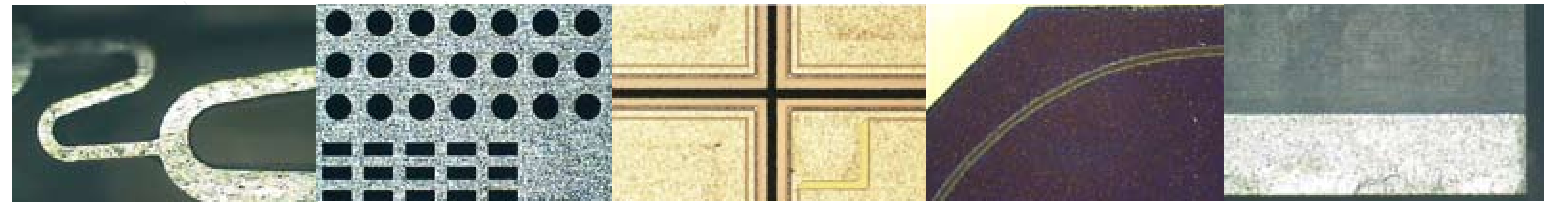
Comparative advantages

The conventional focused laser beam has a limited working distance of just a few millimetres or fractions of a millimetre, due to beam divergence, making precise focussing and distance control necessary, so limiting the ratio of kerf width to depth. In addition, the conventional laser generates a heat-affected zone in the material causing damages such as micro-cracks, structural changes, oxidation or reduced fracture strength. Contamination and deposition are also issues, as the ablated material is re-deposited on the work piece surfaces.

The Laser MicroJet® technology employs a laser beam which is completely reflected at the air-water interface, where the beam can be guided over a distance of up to 10 cm, permitting production of parallel high aspect ratio cut kerfs. No focussing or distance control is required . The water jet cools the cut area eliminating any heat effects, while removing the ablated material from the cut and avoiding contamination.

Conventional Laser	Laser MicroJet®
Requires precise focus adjustment	No focus adjustment required, non-flat surfaces are not an issue, 3D cutting possible, variable cutting depth of up to several cm
Conical laser beam leaves non-parallel kerf walls	Cylindrical beam results in parallel kerf walls, consistent high quality cutting
Limitations in cutting aspect ratio	High aspect ratio, very small kerf widths (< 30 µm possible), minimising material loss, with simultaneous deep cuts possible
Heat affected zone	Water-cooling process avoids thermal damage and material change, high fracture strength is maintained
Particle deposition	A thin water film eliminates particle deposition and contamination, no surface protection layer required
Inefficient material removal leaves burrs	The high kinetic energy of the water jet expels molten material, no burrs form
Diamond Saw	
Limited to straight cutting	Omni-directional cutting, any dicing shape possible
Mechanical stress	No chipping or micro-cracks
Consumables (water + diamond saw blade consumption)	Low running costs, no tool wear, consumes ~1.5 litres water / hour, little or no post-processing required

Stent cutting *Stencil cutting* *Thin wafer dicing* *Solar cell edge isolation* *Hard material cutting*



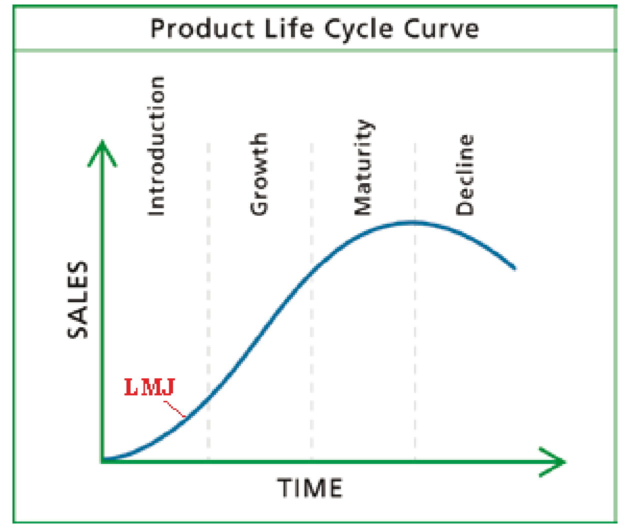
Applications and performance capabilities

Materials	Because the water jet-guided technique is a very gentle process, the Laser MicroJet® is particularly well-suited to handle materials that are very brittle and thus easily damaged or broken by a traditional cutting process. Examples include: • Semiconductors - silicon (Si), gallium arsenide (GaAs), silicon carbide (SiC) • Metals - stainless steel, brass, shape-memory alloys (Nitinol) • Ceramics - aluminium oxide (Al2O3), low-temperature co-fired ceramic (LTCC) • Hard materials - PolyCrystalline Diamond (PCD), cubic Boron Nitride (cBN) and Silicon Nitride (Si3N4)
Thickness	The Laser MicroJet® can cut a wide range of material thicknesses, with few limitations. With silicon, it can process more than 20 mm and up to 2 mm with stainless steel.
Speed	Using the Laser MicroJet® enables extremely high cutting speeds, especially with thin materials: up to 300 mm/s in 50 µm thick silicon, up to 30,000 round holes per hour in 50 µm thick stainless steel (diameter 80 µm).
Accuracy	The lasers used in Synova's process are diode pumped solid state, which can achieve very small kerfs – from 25 to 75 µm – with an absolute precision of +/- 3 µm, resulting in appreciable material savings.
Shapes	The Laser MicroJet® is an omni-directional ablation process, making the creation of any shape possible. This provides customers with the flexibility to develop new ideas and applications, from making hexagonal chips or chips with rounded corners, to combining different sizes of chips on a single wafer, allowing up to 30 percent more chips to fit on a wafer.
Safety	Synova's Laser MicroJet® is an environmentally friendly technology. Even processing of toxic materials, such as GaAs, produces no gas emission. All toxic material is carried away with the water, which can then be simply and economically treated and recycled.

Perspective

Water jet-guided lasers will increasingly replace conventional dry lasers for many applications. The LMJ (Laser MicroJet®) market penetration is today still very low in comparison to what it will be a decade from now. Similar to other system revolutions, a long phase of market pioneering is required, where only innovative early adopters benefit from the invention, finally leading to a fast-growing market penetration, followed by a long maturing phase.

Water/liquid jet guided lasers are actually a second generation of laser cutting systems, which will be mainly adopted for precision machining applications of delicate materials.



In terms of market penetration, the Laser MicroJet® is at the emerging phase of its technological life cycle.