

# Which Technology: Conventional Dry Laser or Water Jet Guided Laser?

By Delphine Perrottet, Simone Amorosi, and Bernold Richerzhagen

Today, lasers are widely used as an industrial cutting tool. They offer many advantages, such as free-shape cutting and high cutting speed. For the last several years, a new technology using lasers has been developed, and this

ilarities in cutting results and, therefore, in application fields.

## Basic Principles

In conventional dry laser cutting, the laser beam has to be focused on the work piece; due to divergence, the beam has a conical shape. The laser

melts and ablates the material by heating at the focal point where the intensity is high enough. An assist gas, coaxial to the

ber. The water jet emitted from the nozzle guides the laser beam by means of total reflection and guides it to the work piece, where the laser is absorbed by the material. The water jet cools the work piece and expels the molten material from the cut.

## The Shape of the Beam

In order to generate a power density sufficient to melt and ablate material, lasers need to be focused. Thus, the depth of the field (area around the focal point where melting is possible) is limited – to no more than a few millimeters or even below (see Fig.1, left). Furthermore, focusing would also be needed with high-power, diffraction-limited lasers.

Guiding a laser inside a water jet creates an “artificial” parallel laser beam that is perfectly cylindrical (no diameter variations) in the context of its stable length. This length is about 1,000 times the water-jet diameter (for example, 50mm for a 50-micron water jet), which corresponds to a working

piece can be placed anywhere inside the stable length, focus-distance control is unnecessary. Consequently, the cutting depth is increased (porous or sandwich structures can be cut), the cutting edges are totally parallel, and corrugated materials can be cut easily.

## Heating

When using lasers, material is molten and ablated through absorption and a consequent heating process. In continuous-wave mode, the thermal load in the material is very high, which make this kind of laser unusable for precision processing. Pulsed lasers reduce thermal load; however, each pulse deposits additional heat into the material (more than is necessary for material removal). This heat, which is not cooled by the assist gas, is conducted into the material, subsequently generating a heat-affected zone (see Fig. 2). Using lasers with short wavelengths and short pulses reduces this effect. The heating effect is eliminated with ultra-short laser pulses, which produces photo-ablation. However, photo-ablation is a very slow process and can never be applied for volume production.

With the laser-microjet technology, heating-related problems are inexistent. Indeed, after each laser pulse, the water jet cools the cut edges, immediately removing the deposited heat so that it is not conducted further into the material. There is consequently no heat-affected zone. Only the edge of the kerf is thermally modified, but the heating does not penetrate into the

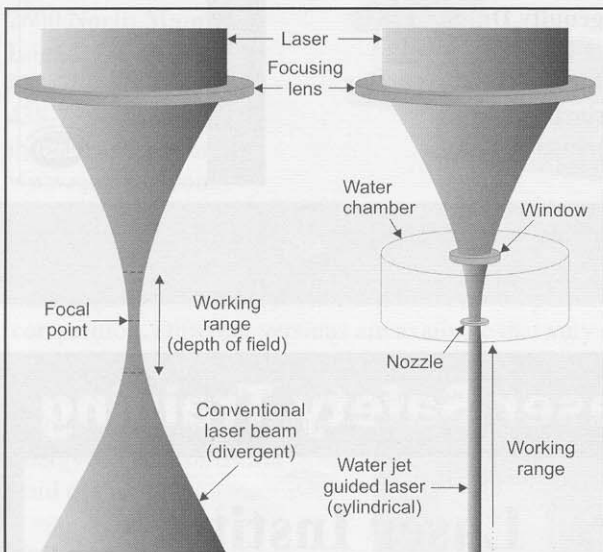


Fig. 1: Conventional laser (left) and Laser-Microjet (right) – Difference in beam shape

technology has the distinctive feature of using a water jet as a guide for the laser beam. These two technologies should not be confused, since there are several major differences that explain significant dissim-

ilarities in cutting results and, therefore, in application fields.

With the water jet guided laser (also called Laser-Microjet®), the laser beam is focused into a nozzle while passing through a water cham-

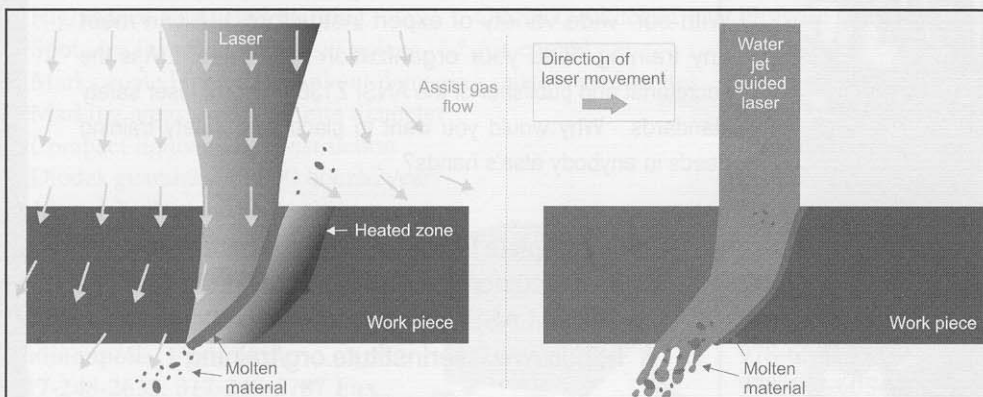


Fig. 2: Conventional laser cutting

material. Therefore, the negative effects of heating, such as micro cracks, oxidation, structural changes or low fracture strength, do not appear.

### Material Removal

After heating, the liquid (or gaseous) material has to be removed. In conventional laser cutting, this task is performed by an assist-gas stream with limited pressure (max. 20 bars). This gas stream is not very efficient, since only a small part of the gas penetrates into the kerf and the kinetic energy is low.

When laser-microjet technology is used, all the water is used to remove the material; furthermore, the water jet involves very high levels of kinetic energy (see Fig.2). Removal by water is thus about 800 times more efficient than by gas. Because the water jet is very thin (with a typical diameter ranging from 75 to 25 microns), the force applied on the work piece is much lower than the force generated by the gas stream, even at high water pressure values (which can reach 500 bars).

### Contamination

Once the molten material is removed, particle deposition on the work-piece surface (contamination) should be avoided. In conventional laser cutting, part of the molten material is deposited onto the surface. The only way to completely avoid these deposits is to add a protective coating during the cutting process and subsequently remove this coating. Because two additional steps are required, this solution is not practiced.

With the water jet-guided laser, if most of the molten material is removed by the water jet, only a small amount of particles remain. To avoid any deposits, a thin film of

water is generated on the surface of the work piece. Particles that fall onto the film are immediately cooled down and cannot adhere to the surface of the work-piece (see Fig. 3).

It is impossible to set up a film of water for conventional dry lasers because it also exhibits an irregular refracting surface that means that the laser's energy density cannot be accurately controlled on the sample.

### Drawbacks of the Water Jet Guided Laser Technology

#### • Wet Process

The fact that the laser-microjet is a wet process may entail problems with some materials that are water-sensitive. The processed pieces need to be dried after the cutting process.

#### • Absorption Coefficient

A wide range of materials can be processed using the laser-microjet; however, materials with low absorption coefficient values such as copper are difficult to cut because they do not absorb the laser light efficiently. Conventional lasers heat the material and increase the absorption coefficient in this way, allowing cutting of low-absorption materials. For example, the laser-microjet can cut copper up to 150 microns thick, whereas conventional laser cutting can produce 1-mm cuts in the same material.

#### • High Aspect Ratio Hole

Drilling of high aspect ratio holes can be problematic because water has to be evacuated; therefore, the aspect ratio

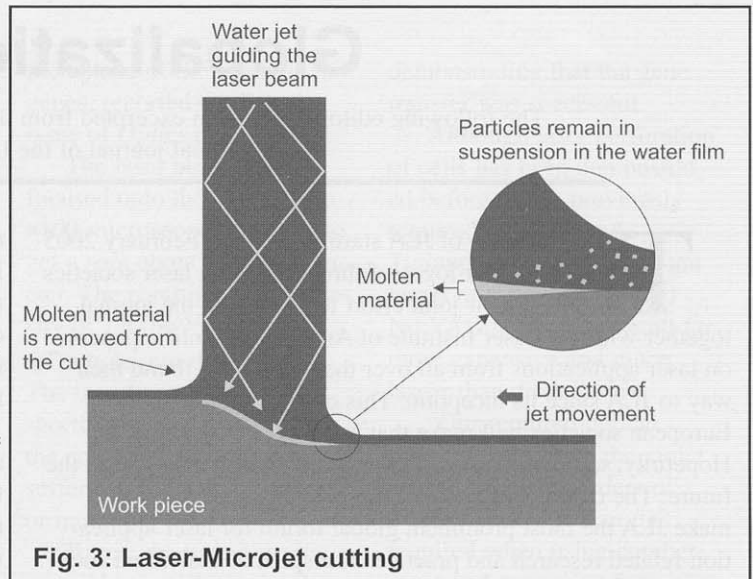


Fig. 3: Laser-Microjet cutting

is limited (around 1:1); in dry laser drilling, the ratio is 1:20.

#### • Machines

Cutting machines have to be designed for water environment. Machines using the laser-microjet technology require additional equipment such as a water pump. Finally, scanning mirrors cannot be used to deviate the jet; consequently, the table or the cutting head should be movable.

### Conclusions

Because both technologies have different characteristics, the two approaches are not used in exactly the same scopes of application. Conventional lasers are effi-

cient for thick metal cutting, drilling of high aspect ratio hole and marking. For applications requiring precision and no damage at all, the water jet guided laser is a more suitable process, and it is mainly used for grooving and cutting. Examples of potential markets for the laser-microjet technology include thin wafer dicing, stencil cutting, and medical stent cutting. \*

*Delphine Perrotet is the press contact, Simone Amorosi the R&D manager, and Bernold Richerzhagen the CEO of Synova SA, Ecublens, Switzerland (+41 21 694 35 00, e-mail perrotet@synova.ch).*

Introducing  
**Power Meters**  
from **Spiricon**

New  
Universal  
Meter

Extensive Probe Choices  
[www.spiriconpower.com](http://www.spiriconpower.com)

**SPIRICON**  
Power Products Inc