

Application Note No. 108

Cutting of Super Hard Materials with SYNOVA Laser-Microjet®

Description of Product

Super hard materials are commonly used as cutting tools due to their hardness and thermal conductivity. This category consists of materials like CBN (cubic boron nitride), PCD (polycrystalline diamond), PCBN (polycrystalline cubic boron nitride), or silicon nitride.



Source: Sumitomo Corporation

Description of Material

CBN is the crystalline form of boron nitride and is chemically inert with most materials. PCD refers to diamond particles that have been sintered together. Synthetic diamond is typically obtained by using a high pressure and temperature synthesis process, which converts the soft graphite carbon into the very hard crystalline form of carbon. PCBN is a composite formed by sintering together CBN particles and metal/ceramic catalyst binder material. Silicon Nitride (Si_3N_4) is a ceramic material of high fracture resistance, hardness, wear, and temperature resistance.

Description of Manufacturing Task

The inserts have to be cut out of a disc or plate. Typical geometries are triangular, rectangular or lozenge-shaped. The main requirements are: smooth edged surfaces, a parallel cutting kerf, and a narrow kerf in order to lose the least material possible. It is also necessary to avoid burrs and material changes due to heating, and to reach reasonable speed and flexibility in order to realize any shape. Drilling is an additional process for fixing of the insert. Typical thickness is between 1 and 4 mm.

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

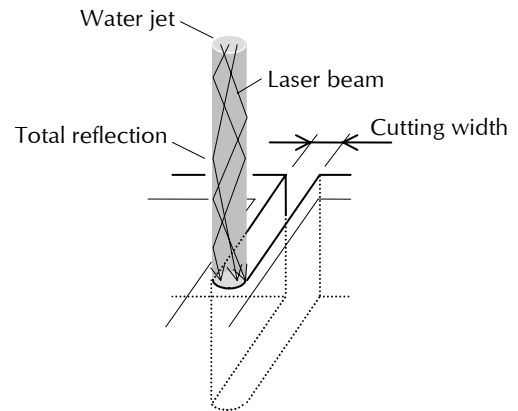
Because of the extremely hard, brittle, and abrasive nature of the ceramic material, diamond wheels and large amounts of liquid coolant are required for all machining operations. The diamond wheel sawing process is slow and tool consuming; in addition very thin gaps cannot be achieved. EDM can only be used in the case of electrically conductive materials, which is not the case of pure CBN, diamond or Silicon Nitride. Conventional laser cutting is possible but induces problems such as post-processing of edges, thermal damages, particles in the kerf, conical kerf shape, and rough edges. Drilling of CBN is possible, but only on a very limited basis.

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 waveguide of variable length.



Cutting with water jet guided laser

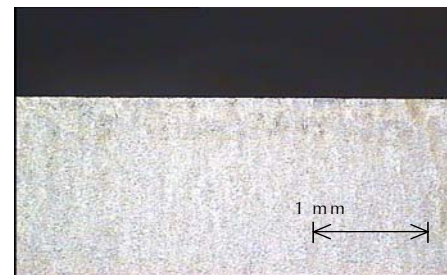
Because a pulsed laser is used, the continuous water jet is able to immediately re-cool the cut, resulting in only a very slight depth of thermal penetration. The result is a very narrow, parallel, burr-free, clean cut, without any thermal damage.

Solution with Laser-Microjet® Process

The Laser-Microjet® allows a fast and precise cutting of super hard materials. The water jet avoids any thermal damage and is able to deposit the laser energy in the bottom of the kerf so that parallel and very narrow kerfs are possible. The tolerances are a magnitude higher than obtained with conventional processes. The laser moves very fast back and forth until the material is cut.

The absorption of the infrared laser radiation in CBN is excellent. The following picture shows the very good quality of the Laser-Microjet® cut edge of a CBN insert (3.2 mm thick).

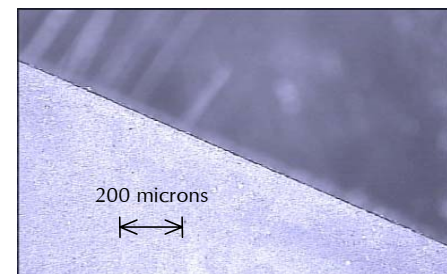
The cutting speed is about 7 mm/min for this 3.2 mm-thick CBN.



Edge of CBN

The synthetic diamond has to be cut with the short pulse laser due to the low absorption. This picture shows the edge of a synthetic diamond piece.

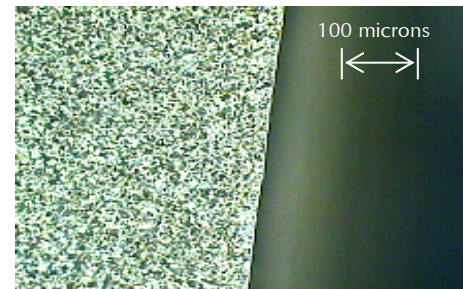
The cutting speed is 1.2 mm/s for this 0.5 mm-thick synthetic diamond.



Line cut of synthetic diamond

This picture shows the excellent cutting quality of a 0.5 mm-thick PCD insert. The use of the green laser has allowed a very good edge quality. Through cut is performed at the speed of 10 mm/min.

The Laser-Microjet enables precise cutting at a high speed whatever the hardness of the material.



Cutting of PCD

Benefit for the customer

The customer now obtains the following advantages:

- ▶ High cutting speed
- ▶ Narrow and parallel kerfs (30 to 100 μm)
- ▶ Very low tolerances
- ▶ No burrs
- ▶ Very smooth surface
- ▶ No thermal damages, no material changes
- ▶ No deposition
- ▶ Drilling possible
- ▶ Kerf is free of particles
- ▶ Very low running costs, no tool wear
- ▶ Constant results
- ▶ Design of insert can be made on CAD
- ▶ Any insert geometry possible:



Consequence of the benefits

Because of the huge improvement in costs, flexibility, quality and productivity compared to any other conventional process as laser, EDM or sawing, the Laser-Microjet[®] process will be the best choice for the cutting of hard material such as CBN, Silicon Nitride or synthetic diamond in the future.

Machine for Laser-Microjet^{®1} Cutting of Super Hard Materials

Synova offers a state-of-the-art, clean-room compatible machine, especially adapted for the cutting of CBN, Silicon Nitride or synthetic diamond. 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^{®2}.

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.

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.

During cutting, the inserts are fixed by vacuum. Synova has developed special vacuum chuck for this application.



Laser Cutting System LCS 300



Laser-Microjet[®] cutting CBN

¹ Laser-Microjet[®] is an international protected trademark of Synova S.A., Switzerland.

² Windows NT[®] is a trademark of Microsoft Corp., USA.