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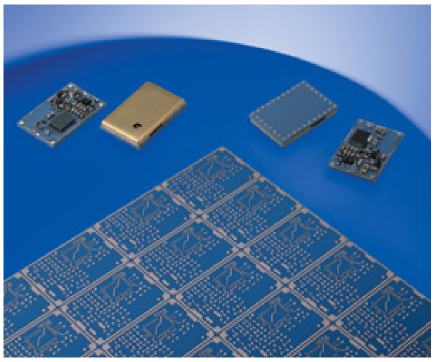
Application Note No. 114

Cutting of Low Temperature Co-fired Ceramics (LTCC) with SYNOVA Laser-Microjet®

Description of Product



Low temperature co-fired ceramics (LTCC) has been developed for the emerging high-speed wireless data communications market. LTCC is extensively used by market leaders in wireless, automotive, medical, broadband communications and test instrumentation electronics. It is a low cost, high performance solution for ceramic packaging.
This technology is defined as a way to produce multilayer circuits with the help of single tapes, which are laminated together and fired in only one step. This improves performance, saves time and money, and reduces circuits dimensions. In addition, in the event of failure, every single layer can be controlled and changed before firing.

Description of Material

Generally, LTCC is made up of glass or glass/ceramic composites. LTCC systems are usually fired at 850 °C and it is therefore possible to use low resistive materials. High conductivity metals, such as silver (Ag), copper (Cu), and gold (Au) are normally utilized as metallization materials (instead of molybdenum and tungsten). Wireless products becoming more and more complex, more passive components are also employed. The co-fired multilayer technique enables the integration of passive components, such as resistors, capacitors and inductors.

Description of Manufacturing Task

LTCC needs to be scribed, grooved, drilled or cut. Scribing occurs either before or after firing. Scribing after firing is more and more common and involves different manufacturing tasks as well as more powerful cutting technology.

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

Scribing before firing may be performed relatively easily; the material is still soft but the results after firing are unpredictable and generally poor. In recent methods, scribing takes place after firing. Several processes are currently used to cut LTCC after firing.

Dicing saw: this common process allows normal quality cuts and holds outside dimensional tolerances. However, this method only works for rectangular shapes and contains several disadvantages, such as: very low grooving speed (2-3 mm/s), chipping of the ceramics close to the groove; crack formation due to mechanical shear stress; high blade wear; short blade lifetime (typically 60 m grooving length); high running costs because of high blade consumption; and unsatisfying positioning precision of front and backside cuts.

Ultrasonic cutter: the cutting is relatively good, but the final part often shows low tolerances, cut may have unexpected shapes, and the process is very slow and expensive.

Conventional laser: the tolerances are tight, but the quality of the edges is very bad. Traditional CO_2 laser has provided significant benefit over the other methods but there are still problems. Users have experienced material cracking, formation of a brittle recast layer, and obstruction of vias with debris.

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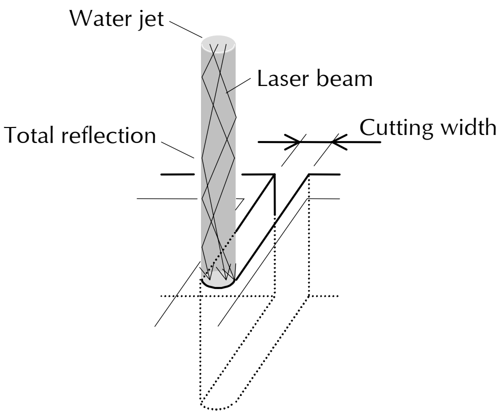
Water Jet Guided Laser Technique

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 fibers. The water jet can thus be referred to as a fluid optical wave-guide of variable length.



Cutting with water jet guided laser

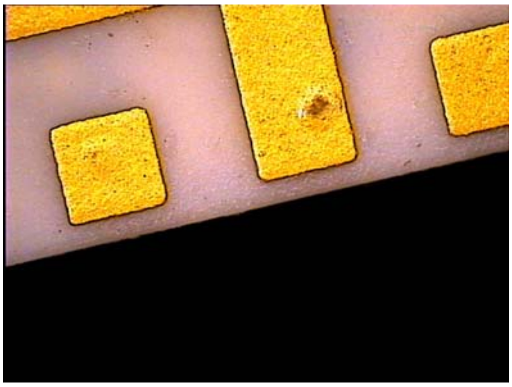
Because a pulsed laser is used, the continuous water jet is able to immediately re-cool the cut, resulting in only a very slight depth of thermal penetration. The result is a very narrow, parallel, burr-free, clean cut, without any thermal damage.

Solution with Laser-Microjet® Process

The Laser-Microjet® is well adapted to LTCC. It can cut, drill or scribe with a high degree of precision, speed and reliability. These following pictures show the excellent cutting quality.

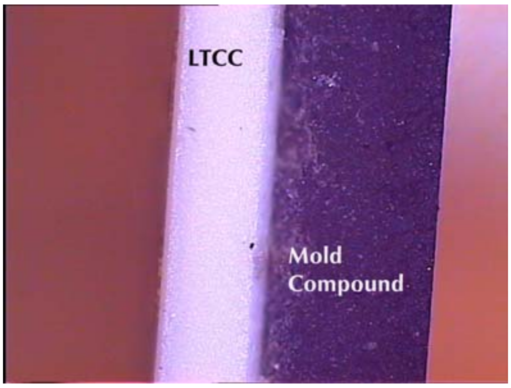
Clean and accurate cutting has been obtained with the 532nm laser. This high quality has been reached with 81W of average laser power at 10 kHz pulse repetition rate and a pulse length of 120 ns.

Other advantages of the water jet guided laser are contamination free surfaces after the grooving, and sharp edged mold compound corners due to the light guidance by the water jet.



Unlike conventional laser, the Laser-Microjet® allows: parallel sidewalls (even in thick mold compound layers); very low thermal load of the sample due to the cooling between the laser pulses exactly at the place where it was heated before; and an efficient expulsion of the ablated material due to the high momentum of the water-jet.

60 microns grooving depth can be reached at a machining speed of 10 mm/s in a single pass.



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Benefit for the Customer

The customer obtains now the following advantages:

- No chipping or cracking
- Smooth, flat bottom surface or kerf
- No burrs or slags, no re-deposition/contamination
- No thermal damage or material changes
- No formation of craters on the edges of the groove
- Smooth vertical walls
- Formation of vias without drill wear or breakage, at a very high speed
- Excellent tolerances
- Possibility of cutting/drilling before and after firing
- Narrow and parallel cuts (35...60 µm)
- Very low running costs, no tool wear
- Any cutting geometry possible (2D)

Consequence of the Benefits

The water jet guided laser allows to join the force of a powerful Nd:YAG laser and the softness of a low pressure water jet. This technology is particularly adapted for critical applications where the fragility of the material or its extreme hardness complicates the machining with other methods. In addition, because of the huge improvement in costs, quality, flexibility and productivity compared to conventional CO_2 laser process, the Laser-Microjet® process will be the future choice for LTCC applications.

Machine for Laser-Microjet®[1] cutting of LTCC

Synova offers a state-of-the-art, clean-room compatible machine, especially adapted for ceramic substrates processing. Optimum cutting parameters are preloaded. The machine designation is LCS 300. Cleaning unit and automatic loading system are available, too. The machine has a precision of +/- 5 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 color 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 option is available such as chiller, alternative laser sources, water treatment system, 2D-reference scales, and transformers.
The CE and S2 certified Synova machines are field proven and used for 24h production.

[1] Laser-Microjet® is an international protected trademark of Synova S.A, Switzerland.
[2] Windows NT® is a trademark of Microsoft Corp, USA.

