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Application Note No. 109

Cutting of Power Semiconductors in Silicon (Thyristors and Diodes) with SYNOVA Laser-Microjet®

Description of Product

Wafers are used in the semiconductor industry for the manufacturing of integrated circuits. Power semiconductors are regulating the supply of electricity by controlling voltages and frequencies. High Voltage thyristors and diodes are used as rectifiers and switches in welding equipment, trains, x-ray machines, generators, power supplies, and others.

Power Semiconductors

Description of Material

Silicon is the basic material used to make wafers; its atomic structure makes this element an ideal semiconductor. Silicon is commonly mixed with other elements in order to modify its conductive properties. The wafer thickness for power semiconductors ranges between 200 and 1500 microns and the diameter varies between 5 and 70 mm, depending on the maximum voltage.

Description of Manufacturing Task

The power semiconductors have to be cut out of a wafer and the ideal geometry of diodes is a circle. The cutting process of silicon wafers requires a high degree of flexibility, no damage to the material and high speed.

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

The cutting of round dies is mainly performed by conventional lasers. However, this technique is not satisfactory. Conventional lasers induce micro-cracks in the edge due to heating, burrs on the backside, slag deposition and particles in the kerf. In addition, the cutting speed is slow and the discs must be protected by a coating, which must be removed later.

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.

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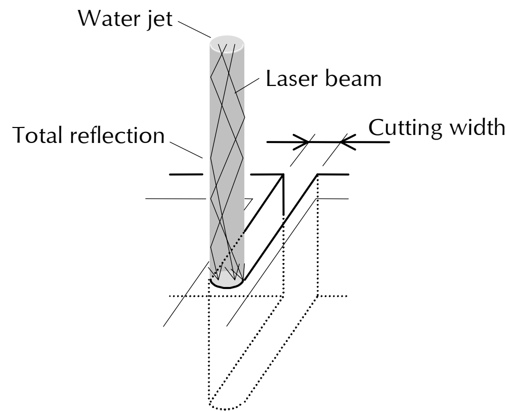
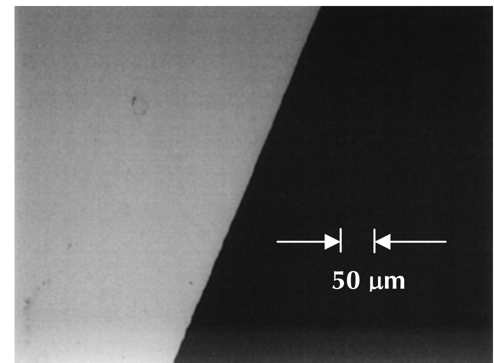
The low-pressure water jet emitted from the nozzle guides the laser beam by means of total reflection at the transition zone between water and air, in a manner similar to conventional glass fibres. The water jet can thus be referred to as a fluid optical wave-guide of variable length. Because a pulsed 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.



Cutting with water jet guided laser

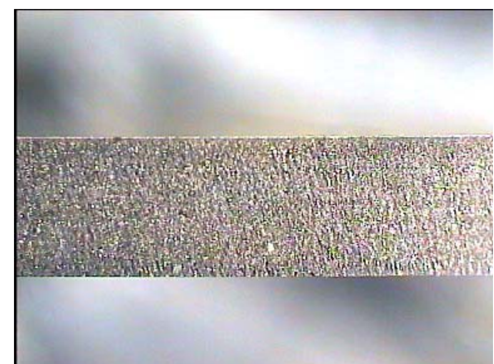
Solution with Laser-Microjet® Process

The Laser-Microjet®, or water jet guided laser, provides a suitable technique for the dicing of power semiconductors. It enables excellent cutting quality. The wafer is protected 100% against any deposition thanks to a water film covering the wafer. Generally, the cutting speed ranges from 50 mm/s for a 200-micron thick wafer to 200 mm/s for a 50-micron thick wafer.



Edge of a cut silicon disc, magnified

This 1500-micron thick wafer was cut at the speed of 1 mm/s. The cutting is free of mechanical stress, thermal damages, contamination, and chipping.



Edge of a power semiconductor (10X)

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Benefit for the Customer

The customer now obtains the following advantages:

- Smooth edge
- No micro cracks
- No material deposition
- No burrs
- No mechanical stress, force free
- No chipping
- Cutting of any shape
- Process can be used for drilling, scribing, grooving, edge grinding, thinning, or marking
- Kerf width from 30 to 80 microns
- Wafer thickness from 25 microns to 5 mm
- LaserTape® can be used like standard dicing tape (available at Furukawa, Japan)
- No tool-wear
- Very few consumables, low running costs

Consequence of the Benefits

Because of the huge improvement in the quality and productivity compared to conventional laser cutting; the Laser-Microjet® process will be the future choice for the cutting of power semiconductors and in general for the cutting of round Silicon discs.

Machine for Laser-Microjet®[1] cutting of Power Semiconductors

Synova offers a state-of-the-art, clean-room compatible machine, especially adapted for the cutting of thin wafers. Optimum cutting parameters are preloaded. The machine designation is LDS 200. Cleaning unit and automatic loading system are available, too. The machine has a precision of +/- 3 microns, a processing area of 240 X 240 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 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.

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

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

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