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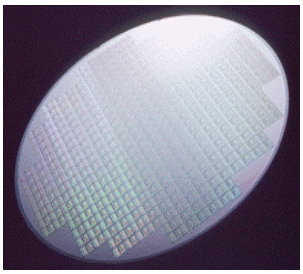
Application Note No. 117

Cutting of Low-k Wafers with SYNOVA Laser-Microjet®



Description of Product

In order to improve chip performance, transistor size in integrated circuits has been shrunk and dielectric materials have been used. The use of low-k dielectric has enabled a reduction of the interconnect capacitance, thus a reduction of the interconnect delay, and therefore an enhancement of performance. A significant improvement was achieved by replacing the aluminum (Al) interconnects with copper (Cu).

Description of Material

Low-k wafers are made of several layers of materials such as silicon substrate, silicon oxycarbide, fluorinated oxide, ceramic, glass, polymers, copper, or oxides of various metals. Low-k materials (k<4) meet requirements such as high mechanical strength, high thermal stability, high thermal conductivity, low moisture absorption and permeation, and high dielectric strength.

Description of Manufacturing Task

Low-k wafers need to be cut, scribed, grooved, or drilled.

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

Low-k wafer processing represents a new challenge to manufacturers. Due to their brittleness, dielectric materials are difficult to dice and require advanced cutting technology. Currently, the main techniques (i.e. blade saw) are not satisfactory.

Blade saws allow acceptable quality cut for standard thick silicon wafers, but this method contains several disadvantages for low-k wafers. Blade sawing causes chipping; crack formation due to mechanical shear stress; blade wear; and high running costs because of high blade consumption.

Lasers have the potential to provide significant benefits over sawing but they still induce problems such as heat damages, contamination, cracking, low speed, and recast. Through-cutting also remains problematical.

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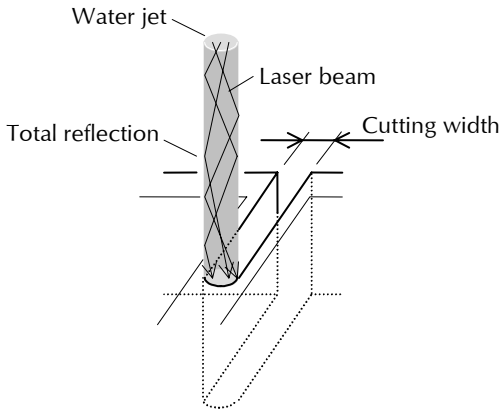
Water Jet Guided Laser Technique

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

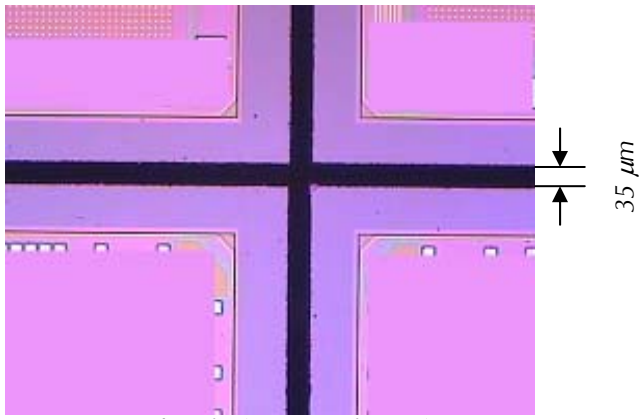
Because a pulsed laser is used, the continuous water jet is able to immediately re-cool the cut, resulting in only a very slight depth of thermal penetration. The result is a very narrow, parallel, burr-free, clean cut, without any thermal damage.

Solution with Laser-Microjet® Process

The Laser-Microjet® is well adapted to low-k wafers. This technique can cut, drill or scribe with a high degree of precision, speed and reliability.

This picture shows the cutting of a 100 µm thick low-k wafer. The cutting is clean and accurate and was performed with a (water jet guided) 532 nm laser. The wafer is cut in 2 passes at a speed of 100 mm/s.

The wafer surface is free of contamination thanks to the use of a thin water film. The cutting street is free of thermal damages, burrs, and chipping. Features of dielectric materials are not affected by the Laser-Microjet® dicing.



Low-k wafer (80x magnification)

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Benefit for the Customer

The customer obtains now the following advantages:

- No chipping or cracking
- No burrs or slags, no re-deposition/contamination
- No thermal damage or material changes
- High cutting speed
- Excellent tolerances
- Narrow and parallel cuts (from 30 to 60 µm)
- Very low running costs, no tool wear
- Any cutting geometry possible (2D)
- Through-cutting with one process

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 laser process, the Laser-Microjet® process will be the future choice for low-k applications.

Machine for Laser-Microjet®[1] cutting of Low-k Wafers

Synova offers a state-of-the-art, clean-room compatible machine, especially adapted for the cutting of dielectric materials. 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.

Laser Dicing System 200

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.

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

