Revving Up Yield With Water-Jet-Guided Laser Technology

For many years, micromachining of semiconductors has represented an insurmountable challenge for laser-based cutting techniques due to the sensitivity of the materials. In fact, until recently, the standard process for wafer dicing has been abrasive sawing. However, the advanced processing demands of emerging devices, such as those based on thin wafers, low-k wafers and on compound semiconductors, are making mechanical methods insufficient, causing chipmakers to look for more sophisticated processing technologies. Swiss company Synova has gone a step further by developing a hybrid dicing technology that combines laser and water-jet technologies to produce a revolutionary, new damage-free dicing solution. The company's water-jet-guided laser offers today's most sophisticated solution for cutting and grooving of thin semiconductors – including advanced compound materials such as gallium arsenide (GaAs) and silicon carbide (SiC).

The Emergence of Water-Jet-Guided Laser Technology

In 1993, scientists at the Swiss Federal Institute of Technology created the world's first laser-light-guiding water jet. Since then, the technology has undergone many refinements to produce today's Laser-Microjet®. While the core technology has remained largely unchanged since its inception, its applications have vastly expanded – one of the most promising being elegant, damage-free dicing of high-value semiconductor wafers.

How Does It Work?

First, a laser beam is focused into a nozzle while passing through a pressurized water chamber. The low-pressure water jet from the nozzle guides the laser beam via total internal reflection at the water/air interface, in a manner similar to that of conventional glass fibers. The pulsed laser and water flow are brought together in a chamber designed to couple the two, letting the water act as a variable-length, optical waveguide. The resulting beam makes narrow, parallel, and burr-free cuts. Water also prevents thermal damage and carries the laser beam to the bottom of the kerf. Accuracy on cutting is an order of magnitude greater than with conventional laser-cutting processes.

Although it uses a laser for material removal, the Laser-Microjet should not be confused with a conventional "dry" laser. The working distance – corresponding to the area where the jet is cylindrical and constant – can be up to several centimeters long, resulting in constant kerf width and no need for focus-distance control; kerf walls are parallel. The water jet prevents heat damage to the material by cooling the cut edges between the laser pulses; the heat-affected zone (HAZ) is negligible. The water jet also expels the molten material about 800 times more efficiently than the assist gas used in conventional laser cutting. The result is a burr-free edge and a higher melt-removal efficiency. Contamination is negligible as a water film is generated on the material surface where the particles, already cooled by the water jet, remain in suspension. This eliminates the need for protective wafer coatings (such as photoresists), thereby further reducing the process cost. Additionally, the force applied by the micro jet is negligible (less than 0.1N), due to its small diameter and medium pressure.

Because it is a very gentle process, the Laser-Microjet is currently used in many different industries. It is also versatile and can be deployed for multiple applications, including cutting, drilling, grooving, scribing, marking and edge grinding. The lasers used are either flash-lamp-pumped pulsed lasers with pulse durations of less than 100 µs, or multimode Q-switched lasers, emitting at 1064 nm (infrared), 532 nm (green), or 355 nm (ultraviolet). For the water jet, pure de-ionized and filtered water, pressurized between 50 and 500 bars – depending on the nozzle diameter – is used. As the jet is only "hair thin," the water consumption is very low – about one liter per hour at 300-bar pressure. The nozzles are composed of sapphire or diamond in order to generate a long, stable water jet, and their diameter ranges from 25 to 100 µm.

The semiconductor and electronics industries are currently the main markets for Synova's Laser-Microjet technology. However, with micromachining required in an increasing number of applications, the process is being adapted regularly to accommodate new materials, new designs and new processing requirements. Examples of emerging microtechnology applications that benefit from the process are cutting of medical stents and dicing of hard-disk-drive (HDD) read-head substrates.

Semiconductor Solutions: Stronger Wafers and Dies

Synova's water-jet-guided laser is the preferred technology for damage-free wafer dicing. Since it generates no thermal or mechanical damage, it can process even the most brittle semiconductor materials, such as GaAs or low-k layers. In fact, recent studies have shown that thin silicon dies are about 1.3 times more resistant when cut

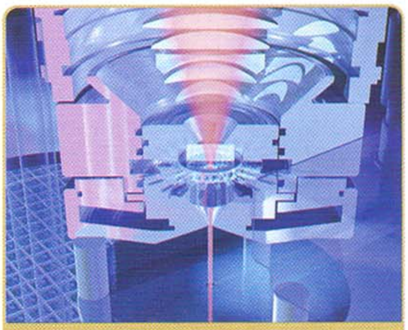

Figure 1. Water-Jet-Guided Laser

with the Laser-Microjet process than when cut with a traditional abrasive saw. The fracture strength of any conventional dry laser is far lower than that of a saw.

The technology is particularly adept at addressing the problem of thin wafer breakage, caused by micro-cracks generated by back grinding. Because these micro-cracks accumulate across the wafer edge, Synova's edge grinding solution – which removes the outer edge of the thin wafer – increases the wafer fracture strength. The result is a significant reduction in wafer breakage during handling. The water-jet-guided laser is currently the only tool that can be used for that task, as it adds no new damage to the wafer and can precisely follow the wafer outline, including the flat or the notch. Furthermore, the process can be applied either before or after back grinding, lending more flexibility to the production line.

Machines Featuring the Laser-Microjet Technology

Synova's high-precision cutting machines enable fast, accurate and omni-directional cutting without chipping, contamination or associated damage. The Laser Dicing System (LDS) is designed for semiconductor wafer back-end processing to include dicing, hole drilling, slotting, grooving, inking, isolating and marking. The Laser Edge-Grinding System (LGS) has been specifically developed to grind the edge of thin, fragile wafers. These state-of-the-art machines are qualified for 24x7 volume production. They feature absolute precision of ± 3 µm and large processing areas that range between 200 x 200 and 600 x 800 mm. The axes are driven by linear motors at the maximum speed of 1000 mm/s. Options include a fully automated handling system, a chiller and a water treatment system, as well as alternative laser sources, reference scales, and transformers.

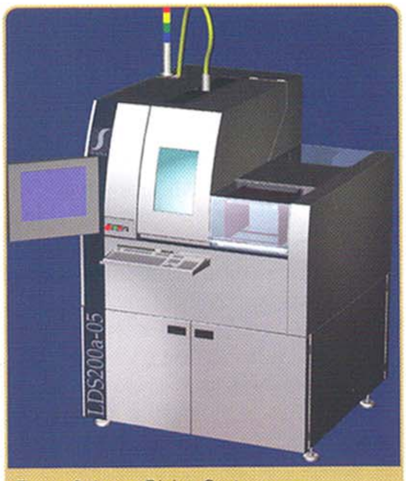

Figure 2. Laser Dicing System

Synova – Serving an Expanded Global Customer Base

Founded in 1997, Synova is a leading supplier of state-of-the-art laser solutions for the semiconductor, electronics, flat panel display (FPD) and industrial micromachining industries, among others. Through its proprietary Laser-Microjet® (water-jet-guided laser) technology, Synova is fast emerging as the ideal provider for addressing the exacting manufacturing specifications and low cost-of-ownership requirements associated with the volume production of today's advanced electronic devices. Headquartered in Lausanne, Switzerland, privately held Synova has subsidiaries located around the globe, including the U.S. and a number of sites in Asia.

In a move to satisfy its burgeoning Asian customer base (which currently accounts for more than 40 percent of Synova's revenue), in April 2005 the company established a wholly owned subsidiary in Japan. This move bolsters its existing Asian infrastructure, adding to the company's established presence in Hong Kong, Korea, Taiwan, China, the Philippines, Singapore, Thailand, Malaysia and India.

SYNOVA

Synova – through its proprietary Laser-Microjet® technology – is a leading supplier of state-of-the-art laser solutions for a wide range of industries.

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