Applications

Water Jets and Lasers Cut Through Electronic Industry's Problems

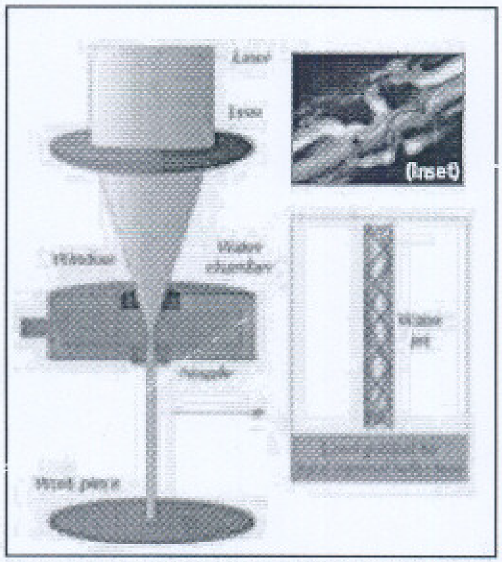
Semiconductor manufacturers need the flexibility of a wafer-cutting machine that supports various wafer sizes and cuts them without the mechanical and thermal damage often seen with traditional cutting methods, including the mechanical stress that occurs with conventional sawing, or the contamination and/or ablated material caused by laser cutting. Employing a dicing process that makes the wafers less prone to breakage would allow manufacturers to introduce thinner wafers into the production line, thereby increasing the number of functions on a given device. A machine that cuts lasers without a heat-affected zone would also offer efficiency advantages to manufacturers.

A number of major semiconductor companies in North America, Europe, and Japan are using Synova S.A.'s (Lausanne, Switzerland) water-guided lasers to eliminate the typical problems inherent in the semiconductor manufacturing industry.

Strengths and Weaknesses

Bernold Richerzhagen, an engineer at the Federal Institute of Technology (EPFL) in Lausanne, Switzerland, thought combining water jets and laser cutting would overcome the limitations of each individual technique.

Traditional water cutting breaks the target material under the pressure of a high-powered water jet. Soft materials such as wood, cardboard, and foodstuffs are well-suited for water jet cutting; adding microscopic particles to the jet stream widens the range of materials to include metal, stone, ceramics, and glass. While water jets require less investment capital and do not emit gas when cutting, water jet cutting imposes a drying step on the manufacturing process, and can mechanically damage the material.



This arterial stent (inset) was machined using a Synova Laser-Microjet system. The laser passes through the pressurized water jet chamber and is contained within the water jet through internal reflection.

Dry laser cutting happens when the material absorbs the energy of the laser and melts or vaporizes. Any residual material left from the cut is expelled by an assist gas. The two drawbacks of laser cutting are thermal damage to the material and contamination when the assist gas does not sufficiently remove the ablated material. In the latter case, a protective coating can be applied to the surface prior to cutting, but this increases costs. Although lasers fit quite well into today's manufacturing processes, they incur higher initial costs than water jet cutting equipment.

To improve both systems, the engineers at the EPFL focused the laser beam into a water nozzle while simultaneously passing the beam through a pressurized water chamber. The low-pressure water jet (lower pressure than the standard water cutting jet) that is emitted from the nozzle guides the laser beam by means of total internal reflection at the water/air interface. Today, the semiconductor field is the primary beneficiary of this innovative technology; however, the water jet-guided laser is also used in an increasing number of other fields, including medical, tooling, and energy.

Best of Both Worlds

The Laser MicroJet technology has a number of advantages over the two traditional methods. In conventional laser cutting, the laser beam is divergent and the working distance is short; focus-distance control is required. This is in addition to the debris concerns and additional protective coating requirements mentioned earlier.

When a water jet guides the laser beam, 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 (the cut between chips in a wafer) and no need for focus-distance control. The water jet expels the molten material. As a water film is generated on the material surface during cutting, the particles, already cooled by the water jet, remain in suspension and cannot adhere to the material. The water jet also prevents heat damage to the material by cooling the cut edges between the laser pulses; the heat-affected zone is negligible compared to conventional lasers.

When compared to non-optical cutting techniques such as abrasive sawing the water jet-guided laser is more flexible — almost any shape can be created. In addition, the running costs are reduced as there is no tool wear leading to blade replacement, and water consumption is significantly lower with the Laser-Microjet approach. Another advantage of the process over sawing is the absence of mechanical damage. Indeed, the force applied by the water jet is negligible (less than 0,1 N) due to the low pressure and small diameter of the jet.

Vision-Guided Cutting

In the semiconductor industry, water jet-guided laser technology (also called Laser-Microjet) is used for various micromachining operations such as wafer dicing and edge grinding, and cutting of hard materials such as CBN and PCD, PV solar cells, and thin metal masks for the electronics industry. Synova uses machine vision to provide the precision motion control necessary for each of its Laser-Microjet systems.

To improve the operating productivity of each system, each Laser-Microjet features Sony cameras (a XC-HR70 and a XC-ES30) connected to a Matrox Meteor-II frame grabber for visual recognition of the work pieces. Depending on the application and system, the image data is processed with the Matrox Imaging Library (MIL) to calculate the required location for the laser. Synova's Laser Dicing System, for example, requires coordinates for the space between the chips, referred to as the street. These coordinates are generated by applying image-processing algorithms to images of the wafer. Image-processing techniques such as blob analysis allow a laser stencil system to detect the openings in metal masks, while geometric pattern recognition determines the cutting path for the laser. In addition to improving quality, the addition of machine vision cuts down on downtime during product turnover and retraining for new product lines.

"We were able to develop the pattern recognition modules we use on our machines far more quickly than without [the Matrox frame grabber]," said Delphine Perrottet, Synova public relations manager. "The Matrox products perfectly correspond to our needs. [The Matrox Imaging] library accompanying the card is very useful. It is a flexible and complete tool, and the engineers found it easy to use."

Experiments are currently underway to determine the Laser Micro-Jet's effectiveness with a smaller jet diameter and to explore new application areas such as free-shape cutting of silicon sensors, metal masks for the FPD industry, HDD parts, and inkjet printer heads.

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