Water jet-guided laser: the solution to new demands in chip singulation

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A new technology is now available to the semiconductor industry that boasts decisive advantages over conventional cutting processes. These advantages will soon make this a widely used tool.

The laser has been used successfully as a cutting tool for almost 20 years, primarily in the field of metal processing. Although silicon is well absorbed by the laser beam, the problems of crack formation, chipping and deposits of silicon slag meant that lasers could not be used for the process of chip singulation. It was not until it was combined with a water jet that the problem was solved.

In 1993, scientists at the Institute for Applied Optics at the Lausanne University of Technology in Switzerland succeeded in creating a laser light-guiding water jet — the Laser-Microjet. The laser beam was focused in a nozzle while passing through a pressurised water chamber. The geometry of the chamber and nozzle is 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 fibres. The water jet can thus be referred to as a fluid optical wave-guide of variable length.

Because a pulsed laser was used, the continuous water jet was able to immediately re-cool the cut, resulting in only a very slight depth of thermal penetration. All the problems of the conventional laser were eliminated.

The cutting speed essentially depends on the wafer thickness — the thicker the material, the greater the requisite laser pulse energy. The maximum cutting speed at a given wafer thickness depends only on the pulse refresh rate and the mean output of the laser, thus ruling out actual limit values between 20 and 120mm/s. The minimum cutting width is actually 50 microns, but there is no limit to reducing the cutting width in the future.

Another important parameter in the comparison between different dicing techniques is the fracture strength of the cutting edges. The thinner the wafer, the greater the importance of this factor. Mechanical deformation (bending) can result in a fracture of the die and its failure. A recent study made by a European chip manufacturer has shown that the water jet laser cut causes significantly less damage at the wafer edges than the conventional dicing saw. Two independent bending tests (with ball and bar) have yielded the same results: a two-fold increase in fracture strength.

One of the major problems with conventional saw cutting is the resultant chipping which can lead to destruction of the die. Chipping is almost thoroughly dispensed with when using the Laser-Microjet.

The saw can only cut in straight lines, with the geometry of the cut being limited to one dimension. The laser, however, allows 2D processing, thus meaning that any contour can be cut. As a result, both holes and slots can now be drilled on one and the same machine — an application for which a particle jet with the associated compromises was hitherto used.

The solution for this is to use a special tape. The prerequisites of such a tape are that it must not be cut with the laser but the water jet must be able to pass through it. Such so-called LaserTape has already been developed and is currently in the test phase. LaserTape will fulfil the same prerequisites as conventional tape, so that it can be used in existing environments without modification.

The running costs of the saw are high on account of the consumption of diamond-edged saw blades and DI water. Furthermore, the manufacturing process has to be stopped for a tool change and the actual change is performed manually. Although more expensive to purchase, the laser is characterised by extremely low running costs.

It will be some time before every expectation can be fulfilled by this new technology, but it has tremendous potential for further development. At present, its limits in terms of kerf width, cutting speed and edge quality can only be guessed.

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