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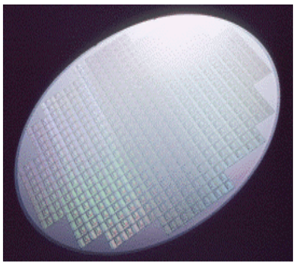
Application Note No. 113

Dicing of Gallium Arsenide Wafers with SYNOVA Laser-Microjet®

Description of Product

Compound materials have indisputable advantages over silicon-based materials, such as higher frequency operation; better signal processing in congested frequency bands; and greater power efficiency. GaAs meets more demanding market requirements, e.g. clock frequency and miniaturization. It is revealing its potential in opto-electronics for applications in the military, the medical, the LED lighting domains, and the wireless communication industry.



Description of Material

Pure compound GaAs contains 51.8 %wt arsenic; it is therefore considered as a hazardous material and is described as toxic by inhalation. Wafers thickness usually varies from 25 microns to 250 microns. GaAs is much more brittle and fragile than silicon. Furthermore, the melting temperature of GaAs is 1238° C and, at temperatures higher than 250° C, it starts to show the phenomenon of thermal runaway. Although GaAs substrate price is not as high as it was, it is still a costly material.

Description of Manufacturing Task

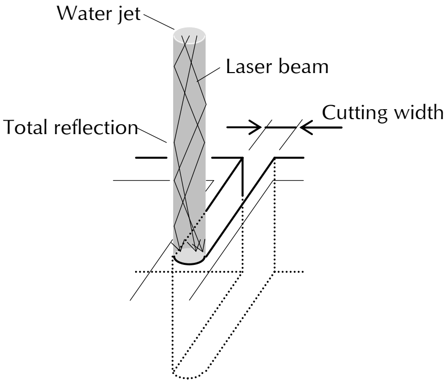
After the wafer is completely processed, it has to be cut into small dies. The dies have typically a size between 0.3 x 0.3 mm and 5 x 5 mm. Due to the material's mechanical and properties, GaAs dicing represents a real challenge.

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

Traditional methods, such as scribe and break and abrasive diamond saw induce mechanical constraints that are unacceptable when dicing GaAs wafers because of the fragility of the material.
The main problems are concerned with: chipping (front and back side); consumption of saw-blades leading to high consumable costs; mechanical stress and the formation of cracks; lack of constant cutting quality due to wear of the saw-blade; very low speed; less suitable for very thin wafers; and only straight contours can be cut.

Water Jet Guided Laser Technique

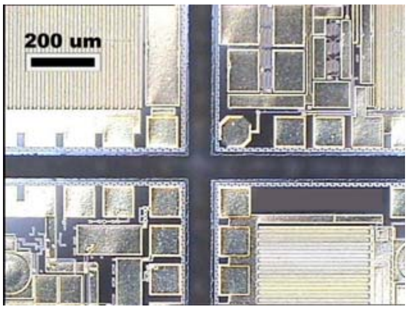
In 1993, Scientists at the Institute for Applied Optics at the Swiss Federal Institute of Technology Lausanne succeeded in creating a laser light guiding water jet, called by its inventors Laser-Microjet® (LMJ technology).
The laser beam is focussed in a nozzle while passing through a pressurised water 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 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

Machining with the Laser-Microjet® Process

Usually, a solid state Nd:YAG infrared (1064 nm) laser is used with LMJ technology. With this type of laser, the achievable cutting speed is up to 8 times faster than with the abrasive saw. The GaAs absorption coefficient of green light (532 nm) being a little bit better than that of infrared light, tests were performed with a 100W green laser in order to determine whether better results could be achieved in term of speed, whilst aiming for the same cutting quality as that achieved with the infrared laser. The results are very outstanding; higher speeds are easily reached with the green laser without any loss in quality, making the LMJ even more attractive for the GaAs industry.



As an example, this 100 µm thick GaAs wafer has been diced at the speed of 40 mm/s in a single pass. The dicing time is 23.5 minutes per wafer or roughly 610 units per minute.

The speed can be increased to 80 mm/s with a quite acceptable quality.

Regarding safety, all the arsine is constrained in the water that can be treated with usual filters.

Benefit for the Customer

The customer obtains now the following advantages:

- High Cutting Speed, 7-10 times higher than the saw
- No chipping and no burrs
- No broken corners even on wafers as thin as 75 microns
- Safety, no arsine gas emanations
- Safe working process
- Omni-directional and free-shape cutting
- No thermal damage or material changes
- Very low running costs, no tool wear and up to 90% reduction in DI water usage
- Higher equipment up time due to no blade or scribe exchanges
- Constant results

Consequence of the Benefits

Because of the significant improvement in costs, quality, flexibility and productivity compared to conventional saw process, the Laser-Microjet® process will be the future choice for GaAs wafers manufacturing.
Regarding safety issues, several tests have been performed with the LMJ and have showed that no arsine gas is detected in the air while cutting GaAs wafers. This is not surprising since the laser beam is coupled in a water jet and laser pulses are very short (around 450 ns). The time for interaction of the laser light with the material is therefore very short and immediately followed by the cooling effect of the water. The concentration of Arsenic in the wastewater is high and the wastewater should to be appropriately filtered or recycled. In brief, the LMJ does not require any other additional safety systems than those employed for the abrasive saw in order to avoid arsine dissipation.

Machine for Laser-Microjet®[1] cutting of GaAs wafers

Synova offers a state-of-the-art, clean-room compatible machine, especially adapted for the cutting of GaAs 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 color screen with touch panel, the machine software is based on Windows NT®[2]. The operation software is easy to use. 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.