SYNOVA S.A.
Chemin de la Dent d'Oche
CH-1024 Ecublens
Tel: + 41 21 694 35 00
Fax: + 41 21 694 35 01
info@synova.ch
www.synova.ch

Application Note No. 116

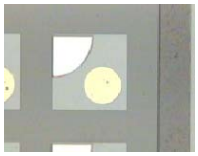
Scribing of GaN-based LEDs with SYNOVA Laser-Microjet®

Description of Product

GaN-based LEDs (light-emitting diodes) are semiconductor devices that emit visible light when electricity is passed through them. Generally, the emitted light is monochromatic and the main benefits of this technology include: low power requirement; high efficiency; and long life. GaN LEDs are mainly used in the manufacturing of displays, signs, traffic signals, automotive lightning, domestic lightning, and medical sensors.

Description of Material

Gallium Nitride (GaN) is a semiconductor compound used for blue, UV, and white (color mixing) LEDs; it allows high output power with small physical volume. The use of GaN has made possible applications, such as daylight visible full color LED displays, white LEDs and blue laser devices. The GaN LEDs typically comprise two thin layers of gallium nitride grown on sapphire or silicon carbide (SiC) substrates.



GaN LED

Description of Manufacturing Task

LED one-step dicing is progressively replaced by a two-step method comprising GaN scribing and substrate cutting. The GaN scribing step must be carried out with a high precision. In order to have good performances, the diodes must have very straight and smooth edges. The cutting of the substrate requires less precision and aims to separate the diodes. Diamond saws as well as scribe (by diamond or laser) and break techniques are normally used for this last step.

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

LED one-step dicing is usually performed by diamond tools and conventional laser. Diamond sawing is generally unsatisfactory; chippings are created around the cuts and the sharpness of diamond tips quickly degrades. This demands frequent replacement, resulting in variable scribe performance and high running costs. Conventional lasers have permitted to reduce the street width but, so far, the results have not been fully satisfactory. Laser processing still reduces LED output, the maximum depth is limited, the cutting speed is low and the problem of heat effects has not been solved.

Because of the numerous problems induced by the present dicing methods, a growing number of manufacturers adopt a best process made up of two steps, namely GaN scribing and substrate cutting. GaN scribing is normally performed by etching. This method provides good quality but is very time consuming (masking, etching and de-masking steps) and therefore expensive. To overcome this problem, Synova has adapted its water jet guided laser for the scribing of GaN-based LEDs.

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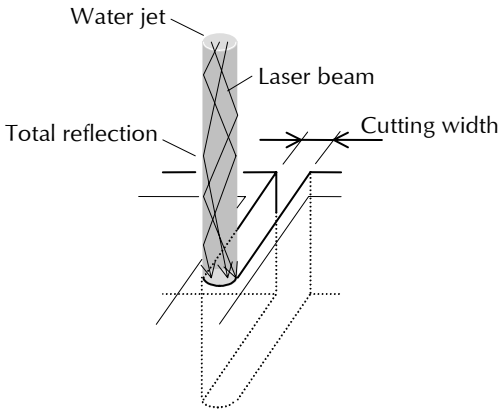
Water Jet Guided Laser Technique

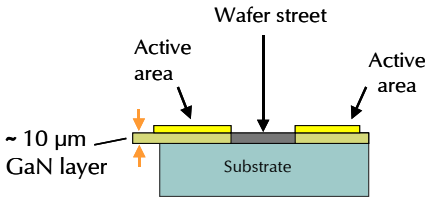
In 1993, scientists at the Institute for Applied Optics at the Swiss Federal Institute of Technology Lausanne succeeded in creating a water jet guided laser, called by its inventors Laser-Microjet®.
The laser beam is focused in a nozzle while passing through a pressurized water chamber. The geometry 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. 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

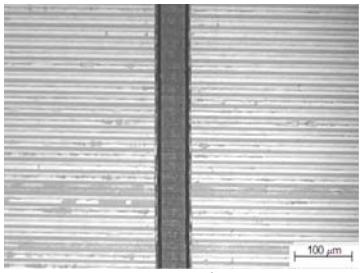
Solution with Laser-Microjet® Process

The water jet guided laser provides an excellent method for the grooving of GaN-based LEDs. The process is performed at a high speed while avoiding shading of emission, heat damages, cracking of edges, and surface contamination. As the surface is constantly cooled by the water jet, the cutting quality is unrivaled compared to other laser processes. In addition, due to the use of a thin water jet (down to 28 µm), it is possible to cut close to the edge of the second layer (maximum 2-3 µm distance) without damaging the optical emitter.



This GaN-based LED was grooved with a 355 nm Nd:YAG Laser guided by a 48 µm water jet diameter. This result was obtained at the speed of 9 mm/s and only one pass was necessary. The groove is free of chipping.

Tests for customers have shown that no LED was damaged during the scribing process and thus the LED output has not been affected.



Grooving of GaN

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Benefit for the Customer

The customer obtains now the following advantages:

- No chipping and cracking of edges
- Excellent edge quality required for the active area
- No contamination of the optical surfaces
- Free of thermal damage
- No shading of emission
- Narrow and parallel cuts (down to 28 µm)
- Precise scribing and grooving
- Fast cutting (up to 9 mm/s)
- Very low running costs, no tool wear
- Constant results

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 sensitiveness complicates the machining with other methods. In addition, because of the huge improvement in costs, quality, flexibility and productivity compared to the etching methods, the Laser-Microjet® process will be the future choice for GaN applications.

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

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

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

