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Application Note No. 121

Scribing/Ablation of Thin Films with SYNOVA Laser-Microjet®

Description of Product

Thin-film layers of material, varying from fractions of a nanometer to several micrometers in thickness, are often deposited onto a substrate, or on top of another previously deposited layers. The technique is used in many manufacturing processes, typical example are: optics (for reflective or anti-reflective coatings), electronics (layers of insulators, semiconductors, and conductors in integrated circuits), photovoltaic (PV) cells and in packaging (i.e., aluminium-coated PET film).

Thin-film Photovoltaic Solar Cell

Description of Material

The substrates can be composed of glass, plastic, metal, bulk silicon or ceramic materials. The thin films deposited are typically materials (insulating, conducting or absorption) used for the manufacturing of integrated circuits, solar cells, for use in anti-reflective coatings of automobile windscreens or optics and more recently with ferromagnetic films for computer memory devices. The process is also used for applying ceramic thin films for the protection of substrate materials or as a coating for machine tools. Thin-film technologies using c-Si, a-Si:H, CuInSe2 (CIS), or CdTe are now being developed as a means of substantially reducing the cost of PV systems.

Description of Manufacturing Task

Thin-film deposition techniques fall into two broad categories, depending on whether the process is primarily chemical, known as Chemical Vapour Deposition (CVD) or physical, known as Physical Vapour Deposition (PVD), better known nowadays as vacuum deposition. The most common method in use today is Low Pressure Chemical Vapour Deposition (LP-CVD). "Thin" is a relative term, but most deposition techniques allow layer thickness to be controlled within a few tens of nanometers, and some (molecular beam epitaxy) allow single layers of atoms to be deposited at a time. The manufacturer then typically has to scribe or ablate all or part of the thin-film to produce the finished article, as in the case of large area thin film PV arrays.

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

Scribing or ablating areas of these thin films, possibly preserving all or part of a lower layer, or going down completely to the substrate, has mainly been accomplished up until now using etching techniques (either electro-chemical or plasma), diamond scribing or conventional laser ablation. Etching requires a mask to function, adding to the manufacturing requirements and costs. Chemical etching is also not an environmentally friendly process due to the nature of the chemicals used. Diamond scribing has several disadvantages such as difficult height control, wear or mechanical damages. Laser ablation generates heat damages and contamination.

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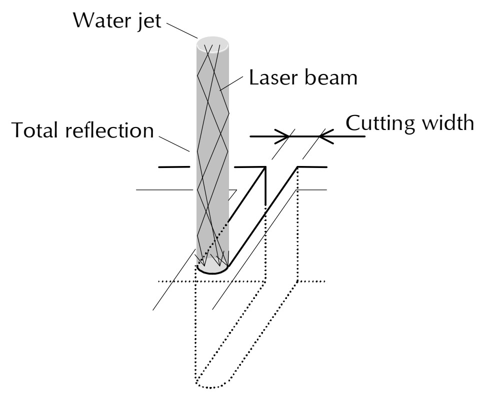
Water Jet-Guided Laser Technique

In 1993, scientists at the Institute for Applied Optics at the Swiss Federal Institute of Technology in Lausanne succeeded in creating a water jet-guided laser, referred to as the Laser Microjet® by its inventors.

The laser beam is focused through a nozzle while passing through a pressurized water chamber. The geometry of the chamber and nozzle are critical 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 internal 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.



Cutting with water jet-guided laser

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.

Laser-Microjet® Solutions

Scribing/Ablation with Laser MicroJet®

As a "cold" and "wet' laser, the Laser MicroJet® (LMJ) is perfectly suited for high-precision scribing/ablation of thin-film layers.

Accuracy is combined with speed. The material ablation is entirely free of mechanical and thermal damage.

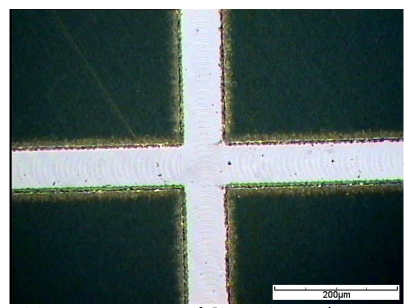
The LMJ can scribe/ablate all applied thin-film layers, or selectively remove one or more top surface layers, with no de-lamination, leaving the underlying layers untouched.

The LMJ is able to scribe/ablate any type of line (straight or curved) or open form 2D shape in the thin-film layers. Thanks to the extreme working distance non-flat surfaces can be processed fast and easily.

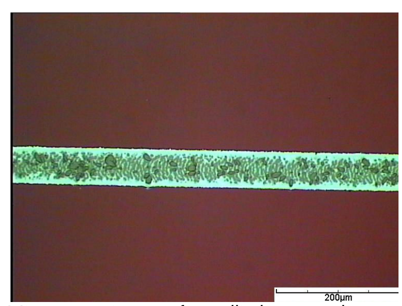
The process produces very smooth and straight edges, as well as burr-free cuts.

Parallel and narrow kerf cuts can be obtained which allows for a better functionality of the devices and provides for increased surface area in the case of PV cells.

The LMJ is environmentally friendly as only De-Ionised (DI) water is required during cutting (<1 litre/hour).



Microscope image of CIS + Mo on glass, cut with Laser MicroJet®, groove width ~70µm, electrical isolation R>20MΩ



Microscope image of metallic layer on glass, cut with Laser MicroJet® (front view); groove width ~65µm, electrical isolation R>1MΩ

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<u>Customer Benefits</u>

Customers can obtain the following advantages using Laser MicroJet® technology:

- High speed cutting
- Excellent cutting quality with narrow and parallel-cut kerf walls, and smooth and straight edges
- No burrs or depositions maintaining a very smooth surface
- No mechanical damage; water exerts very low (<0.1N) forces on the work piece
- No heating of the parts or thermal deformation
- No contamination or re-deposition
- No chipping
- Consistent results
- Very low running costs; no tool wear
- Higher throughput and productivity and better return on investment
- Environmentally friendly process as only DI water is required, ablated materials are removed with the water for later filtering and disposal

<u>Consequence of the benefits</u>

Because of the significant speed improvements over etching techniques, and in particular, the low mechanical stress on the material, the Laser MicroJet® process is proving to be the ideal method for scribing/ablating of thin film manufactured items.

<u>Laser MicroJet®[1] Cutting System for Thin Film Scribing/Ablation Applications</u>

Synova offers a range of state-of-the-art, clean room compatible machines, including the illustrated LCS 300 and LSS 1200 laser cutting systems, which can also perform scribing/ablation functions. Standard laser types are either 1064 or 532nm pulsed diode pumped solid state Nd:YAG.

These systems have a processing area from 300x300 mm up to 1200 x 900 mm, a precision of ± 3 microns, and a maximum axis velocity of 1000 mm/s. All systems are equipped with a CCD camera and fast image processing software, allowing automatic alignment and inspection. The user interface is a flat colour touch panel display. The machine software is based on the Windows®[2] operating system.

The Laser MicroJet® Systems can be connected to a LAN network for data transmission and remote diagnostic services. Adapted CAM software can convert all DXF data, quickly and economically, with no special knowledge or training requirements.

Options include water chillers, alternative laser sources (i.e. UV), water treatment system, 2D-reference scales and transformers. The CE and S2 certified Synova machines are field-proven and in use in 24/7 production environments.

Synova Laser Cutting System

[1] Laser MicroJet® is an internationally protected trademark of Synova S.A., Ecublens, Switzerland.
[2] Windows® is a trademark of Microsoft Corp., USA.