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FUSION OF DIAMOND BLADE SAW WITH WATER JET-GUIDED LASER TECHNOLOGY TO YIELD REVOLUTIONARY DICING SOLUTION

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Biography

Dr. Tuan Anh Mai received his Dipl.-Ing. (MSc) in mechanical engineering at the University of Ilmenau (Germany) and his Dr.-Ing. (PhD) in materials engineering at the University of Hannover (Germany). Dr. Mai has been working in the field of optics and laser materials processing, especially in developing and customizing laser micromachining processes and systems since 1984. He worked at the Laser Zentrum Hannover and Singapore Institute of Manufacturing Technology as a research scientist and project manager. Before joining Synova as an R&D Manager, he worked in the Netherlands for a laser wafer dicing company as Process Development and Application Manager.

Abstract:

The insatiable demand for smaller, more feature-packed consumer products has posed new challenges to Integrated Circuit manufacturers, who must now squeeze more and more functionality into ever-smaller packages. One of the major challenges facing the packaging industry in this regard is that chipmakers have introduced new wafer materials with more complex layers, making them brittle and damage-prone when undergoing traditional dicing technology. This paper presents a unique hybrid dicing tool, combining Synova's patented water jet-guided technology with Disco's latest-generation diamond blade-saw dicing systems, for advanced-dicing applications. The fully automatic hybrid laser saw being jointly developed with one mechanical spindle and one laser MicroJet module, provides a dicing solution for both current and next-generation IC's. This hybrid solution enables semiconductor manufacturers to meet their dual need for higher throughput and high cutting performance combined with no backside-chipping, minimal damage to the semiconductor wafer and to the emerging genre of advanced material wafers of any thickness. The hybrid-dicing machine is also integrated with a cleaning station and a unit for irradiation of UV dicing tapes. The machine is sized to accommodate wafers up to 300mm in diameter. Different dicing modes are available such as, laser cut only, pre-dicing plus laser cut, and pre-laser plus dicing. Dicing examples illustrate that the fusion of these two technologies result in the best dicing system that both companies can offer.

Introduction:

The original idea for developing a hybrid dicing and cutting solution for the semiconductor industry was first proposed several years ago internally in Synova. It was recognised at that time, that the advantages to be gained in blending the widely used diamond blade saw with the water jet-guided laser, also known as the Laser MicroJet® (LMJ), would provide an advanced next generation tool for the industry. The concept has now become reality following the agreement between Disco Hi-Tec Europe GmbH and Synova SA to jointly develop the machine and processes.

Description:

The Hybrid Laser Saw (HLS) machine consists of a modified high performance Disco dual parallel spindle DFD6361 series saw, which can perform wafer loading, alignment, cutting, cleaning, drying and unloading fully automatically. The machines, which can accommodate wafers up to Ø300mm, are normally used for such dual-spindle applications as step cuts, bevel cuts, and dual cutting. In addition to silicon wafer dicing, they can handle ceramics, package singulation, and a wide variety of cutting and dicing tasks.

The modified version combining the two technologies, has one of the two saw blades removed and replaced by a LMJ optical head module, which is shown in the following Figure 1.

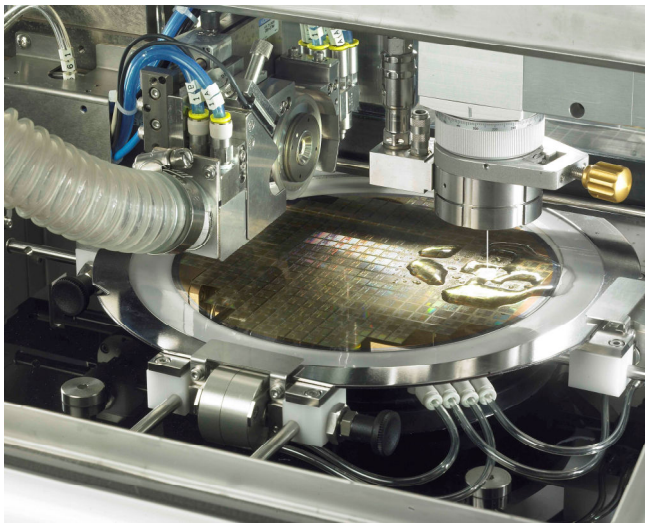


Figure 1 View showing Disco blade saw and the Synova LMJ optical head integration

The Hybrid Dicing™ process, permits the best of both worlds for the cutting and dicing of both present day and future semiconductor products.

As a standard blade saw, the HLS can cut/dice wafer, providing the same quality, speed and dependable performance provided by all Disco machines.

The integration of the Synova LMJ optical head provides additional high quality cutting capability to process wafer where a standard saw does not perform as well due to chipping, such as with thin wafer, low-k materials, Class III-V compound semiconductors, wafer with metal or oxide layers, etc.

The optical head assembly is the same part as is installed in standard dicing, cutting, edge grinding and stencil machines delivered by Synova. The head receives laser light from an external 1064 or 532nm Diode-Pumped Solid-State (DPSS) laser, and focuses the beam into a hair thin jet of water, where it is guided by means of total internal reflection to the work piece, as shown in Figure 2 [1,2].

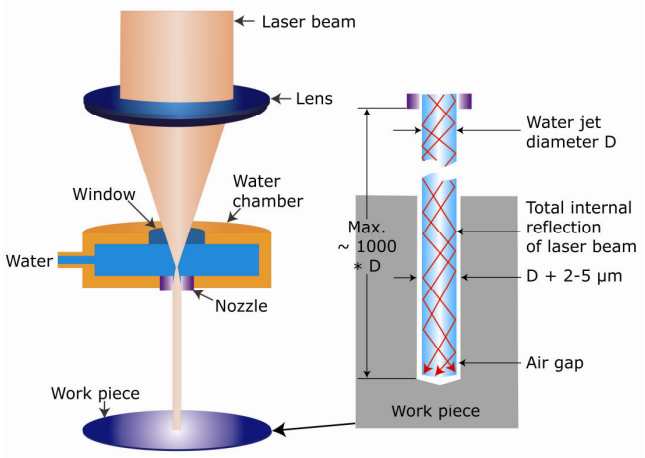


Figure 2 LMJ principle

As can be seen from the image, the laser beam does not suffer from the most serious deficiency of standard dry lasers, as there is no divergence of the beam, which would otherwise result in limited depth of cut. The nozzle sizes used can range from 30 to 80µm depending on requirements. Due to the vena constricta effect, the resulting jet is approximately 15% smaller in diameter.

The water jet provides a continuous cooling medium to the cut edges during the lasers pulsed operation, resulting in no detectable thermal damage to the material. The low pressure water also expels ablated material from the kerf and prevents any contamination or re-deposition on

the work piece surfaces, eliminating the requirement for surface protection measures. The LMJ also improves cutting quality, since it does not exert mechanical forces (<0.1N) on the work piece. This reduces possible material structural damage, which would otherwise result in micro-cracking and reduced fracture strength of the wafer.

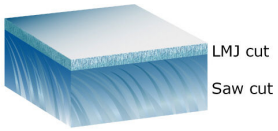
The HLS, due to its flexibility will provide for a large number of operational scenarios for the cutting and dicing of semiconductor materials, especially in the case of multi-layered, low-k or wafer with metallised layers. These materials will especially benefit from the machines ability to process a common work piece with both tools operating in parallel, but each one carrying out an independent procedures.

This two in one complete solution will greatly reduce overall wafer processing time, providing increased profitability for the user and an improved return on investment, requiring the purchase of only one instead of two or more tools to accomplish the same result.

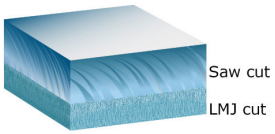
The HLS will be delivered as a turnkey package for integration into existing or new production facilities. The only consumable required, besides saw blades, is a common supply of de- ionised, de-gassed and filtered water.

Several different modes of cutting or dicing are foreseen, depending on the base material. These can be broken down as follows:

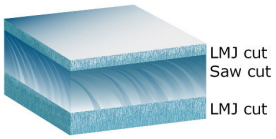
1) First LMJ then saw



2) First saw then LMJ



3) First LMJ then saw followed by LMJ



4) LMJ only
5) Saw only

The first case 1) is appropriate for wafer where the top surface consists of metal or oxide layers followed by bulk silicon. The LMJ will first cut an opening through the delicate top layers, which can then be followed by the saw, to finish the process.

The second case 2) is for wafer where a high quality back surface with no chipping is required.

The third case 3) is for when both the top and back surfaces are required to have the highest quality and be chip and burr free.

The fourth case 4) is when thin wafer is to be cut or diced, a process where the LMJ has proven its superior performance. As an example, it can cut 50µm material at speeds up to 300mm/s providing very high quality results, which other technologies can not achieve.

Finally the fifth case 5) is for for the simple cutting of bulk material, where production speed is the only governing factor.

Use of the LMJ in cases 1) to 3) for making the initial cuts through the top or back surface layers, will result in considerably reduced operating costs. Blade wear in cutting these layers would otherwise considerably reduce their usefull lifetime, requiring more frequent blade replacement.

It should be noted, that all of the above processes are fully compatible with the use of suitable industry standard dicing tapes. There are no special tape requirements when using the LMJ.

Conclusion:

The HLS dual tool provides the user with the best of both worlds, conventional sawing and LMJ cutting, enabling high processing speeds and top quality at the same time. The blade-saw is unbeatable in speed for cutting through bulk

silicon; the LMJ technology is unrivaled when processing delicate materials and layers, with negligible material damage (insignificant heat affected zone (HAZ), and no burrs, contamination, chipping, etc.,).

The combination of the strengths of these two existing technologies / processes in one machine makes the HLS an even lower cost per unit manufacturing tool. The greatly reduced mechanical stress and damage results in a significantly better chip yield, whilst the reduced usage of the diamond saw blade decreases machine-running costs, generating significant savings. And lastly, shortening the processing chain by at least one machine platform due to the combined tool, increases return on investment and reduces the cost of ownership.

References:

[1] Richerzhagen, B. The Best of Both Worlds – Laser and Water Combine in a New Process: The Water Jet Guided Laser, in proceedings ICALEO 2001.

[2] Battaglia, J., Perrottet, D., Housh, R., Richerzhagen, B., Synova has re-invented the laser: No heat damage, no beam divergence, no cutting gas, no deposition, Paper M905, ICALEO 2006.