Laser system manufacturers vie to open up new markets

Having carved out a niche in back-end processing of sapphire and SiC wafers over the past couple of years, some laser tool manufacturers are now targeting GaAs and InP wafers. Meanwhile, others believe that these material systems will remain the preserve of diamond scribe tools and saws.

Until a couple of years ago, scribe dicing with a diamond tool was the preferred method for dicing virtually all compound semiconductor devices. However, the traditional scribe tool is far from ideal when it comes to processing GaN-based devices grown on sapphire or silicon carbide substrates.

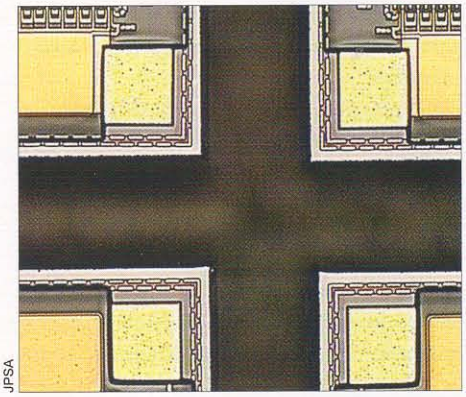
The problem is substrate hardness. The sharpness of diamond tips quickly degrades, which demands frequent replacement, resulting in variable scribe performance and reduced overall yields.

As a result of the problems associated with the diamond scribe tools, lasers have been able to penetrate the sapphire substrate market. Two US companies that have moved quickly to exploit the problems of diamond scribing are JP Sercel Associates (JPSA) and New Wave Research. The advantages are obvious, according to JPSA president Jeff Sercel: "With JPSA's method, the street width can be reduced to 20 μm (for 250 × 250 μm devices) for a typical 2 inch blue LED wafer on sapphire." This would give a 14% increase in die compared with diamond scribers that give 50 μm streets at the same device size.

"It is fair to say that laser scribing has become the new industry standard in cases where the wafer materials are very hard, such as silicon carbide and sapphire," added Sercel. "Most of the major players in the [sapphire LED] industry are either currently using or adopting laser die separation technology."

New Wave marketing vice-president May Su estimates that laser-based systems account for as much as 90% of the new capital equipment spending on scribers in Taiwanese sapphire-based LED manufacturing. She says that New Wave now has around 40 laser units installed worldwide.

According to Su, the company's latest system processes 350 × 350 μm die on 50 mm sapphire wafers at a rate of more than three wafers per hour (JPSA claims that up to eight wafers per hour are possible with its system). New Wave claims that its laser system has reduced LED-scribing costs by over half compared with diamond scribing, while simultaneously improving throughput.



JPSA

JPSA is now targeting the GaAs sector with its laser-scribing tools. This image shows a wafer intersection scribed with the company's new system, which has a cut width of 5 μm and can dice 10 wafers per hour.

Performance trade-off

Laser processing of LED wafers does come with a trade-off in device performance, however. The extent of this trade-off is contentious.

While Sercel admits that laser processing does reduce LED output, he says that the laser systems which use a longer wavelength have a much more profound effect than the ultraviolet lasers in JPSA systems. "We have heard estimates of 10–20% light loss with longer-wavelength lasers. Our customers report far less light loss, 2–5% in production. At these levels it does not seem to be a problem."

Having installed its first six laser scribing systems in mid-2002, New Wave has enjoyed considerable success in the Taiwanese market. Su says that the greater emphasis on cost reduction at Taiwanese LED manufacturers made it the obvious entry point for laser scribers. New Wave appears to have also convinced one Japanese LED manufacturer – who typically put more emphasis on quality – that problems with the light-output quality of laser-scribed wafers are a thing of the past. New Wave installed its first laser-based sapphire scriber to a HB-LED manufacturer in Japan about a year ago, although Su admits business has been slow since.

Another common criticism of laser processing is the appearance of "burnt" wafers caused by the heating effect of the lasers. According to Sercel, the actual mechanism of the material removal relies on ablation rather than melting. This is due to the short wavelength of light and the short pulse durations used. "The result is a far less thermal process than directly vaporizing sapphire," he said. JPSA has a patent pending relating to the precise nature of this ablation mechanism.

Diamond tool manufacturers are also looking to partner laser-scribing companies by providing the breaking technology that is still needed. This is also the strategy being pursued by Dynatex, a diamond tool manufacturer, which previously specialized in the breaking aspect of the process. Leanne Schmidt, Dynatex's marketing manager, says that while laser cutting has undoubtedly had an impact on the sapphire-based LED market, there will always be a need for diamond scribers in the broader compound semiconductor sector. Schmidt told *Compound Semiconductor* the scribe-and-break technology provides a dry mechanical process avoiding water or heat damage. "Ultimately, throughput will determine the process technology," she said.

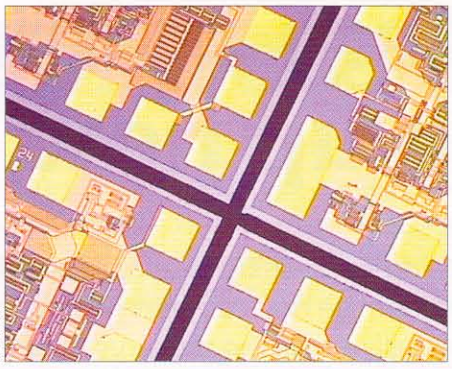
Lasers take on GaAs

While diamond scriber specialists such as Dynatex look to reclaim some market share in sapphire and silicon carbide applications, laser companies are looking to consolidate their positions and penetrate other aspects of the industry.

Diamond scribe tools and saws still have a stranglehold on GaAs wafer dicing, with diamond scribers typically used for optoelectronic applications and saws for microelectronics, but laser system builders now have this segment of the compound semiconductor industry in their sights too. "Our laser-dicing technology is well suited to GaAs and InP wafers and others," Sercel told *Compound Semiconductor*. "Many of the devices themselves are thermally sensitive, requiring a great deal of laser finesse and expertise to handle properly."

However, question marks hang over the safety aspects of laser-dicing GaAs wafers, because of the potentially harmful side-effects. This is a fact that Sercel acknowledges: "We have long known that we can scribe GaAs, but we were reluctant to do a large amount of research and development because of the toxicity of arsenic."

Sercel says that JPSA has now developed scrubber and waste-handling equipment for safe laser-dicing of GaAs wafers. "Our work has caused a great deal of excitement with the GaAs people."



SYNOVA

A 75 μm GaAs wafer diced with the 40 μm diameter Laser-Microjet from Swiss company Synova. The cutting speed was 36 mm/s.

Having apparently overcome the safety issues, JPSA has just released details of a new laser-scribing process for GaAs microelectronics applications. Sercel says that the process cuts down to a 5 μm kerf width in thin or thick wafers, with no edge chipping. "GaAs wafers are expensive, so wafer real estate is valuable," he said. "[Our] process operates within 20 μm streets or narrower."

One European laser company already claims to have scored a success in the GaAs market. Netherlands-based Advanced Laser Separation International (ALSI) says it has shipped a machine capable of dicing GaAs-based wafers using a 40 W solid-state laser to a manufacturer of both LEDs and microelectronic devices. According to ALSI's René Hendriks, who believes the system to be the first such deployment worldwide, installation tests on the LED production line have been completed and the system has now been accepted for full production. Hendriks says that the key advantage of the ALSI laser is its speed, which he claims is 20–40 times faster than mechanical saws with a dicing speed of 200–400 mm/s.

The wafer is protected by a coating during dicing and Hendriks says that no impact on LED output has been detected. Originally developed by consumer electronics giant Philips, the ALSI system features multibeam optical delivery that produces 3–14 dicing beams. Hendriks told *Compound Semiconductor* that InP and SiC wafers could also be diced using the same system fitted with a different laser source. The ALSI system produces a kerf width of 15–18 μm.

Innovative set-up

Another European company with an innovative laser set-up is Synova of Switzerland. Synova's technology features a water jet that acts like a fluid fiber-optic guide for the laser. The company claims that the water jet also negates the sometimes damaging effects of laser heating on devices. Sales manager Roy Housh says that rather than having any negative effects on the wafer being diced, the water jet cools between laser pulses, avoiding heat damage. "Deposits and heat are a problem with conventional lasers, regardless of the wavelength and other parameters," he explained.

Housh says that the water-jet system has already been used to dice silicon, GaAs, GaN and SiC substrates. He told *Compound Semiconductor* that the laser can be switched easily between different wavelengths that suit a particular substrate material. Depending on the material being cut, infrared, green or ultraviolet wavelengths are used.

The water-jet system could also replace the two-step scribe-and-break technique with a one-step approach that cuts straight through the wafer, according to Housh. "We can cut a GaAs wafer in 11–30 minutes, depending on the customer's requirements," he claimed.

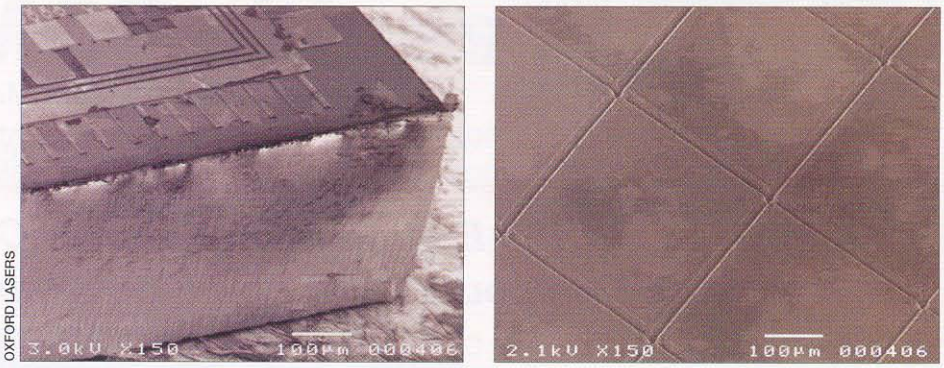
Also targeting the compound semiconduc-

tor market with lasers is the UK-based Oxford Lasers. The company has developed a number of customized systems designed for both scribing and cutting sapphire.

However, Oxford Lasers' Alan Ferguson believes that it is still very early days for lasers to penetrate the GaAs market. "The key role for lasers in this arena will be to drive production costs down," he said, although he admits that some customers working with InP and GaAs have approached Oxford Lasers.

However, Oxford Lasers is predominantly concentrating on sapphire scribing and dicing systems. Ferguson says that Oxford's products can dice through sapphire up to 700 μm thick without the need for a breaking step. "This system is particularly good where the components required have relatively large dimensions," he said.

While Ferguson admits that in the early days there were problems with laser "burning" of sapphire wafers, he says that recent experiments at a UK university that Oxford Lasers is working with have shown that LED performance is only "minimally" affected by laser scribing.



Oxford Lasers' 255 nm laser has cut straight through this 400 μm sapphire component (left), eliminating the need for a breaking step. The image on the right shows 30 μm deep scribes on a 100 μm thick sapphire wafer, also cut with a 255 nm laser.

Exactly which GaAs device manufacturers are already using, or are looking to use, laser dicing is not widely known, although RF Micro Devices is rumored to be testing just such a system.

Looking forward, the wafer-scribing market could be set for more changes. Su believes that laser technology will dominate sapphire applications for the next few years, but predicts that the available market will start to plateau and eventually decline once more convenient substrate materials become utilized. She says that New Wave is already looking at how lasers can be implemented in future manufacturing processes.

● This article was compiled using information supplied by manufacturers of laser scribing and dicing equipment. Next month, we talk to diamond tool manufacturers about the advantages of diamond scribe techniques.