Introduction of Plasma Scribing Technology on GaAs Wafers Using ICP Etching

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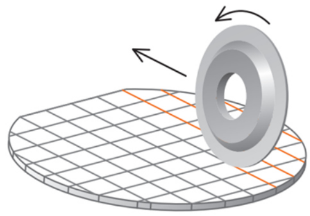
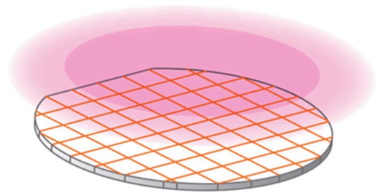
Introduction

GaAs-based devices find applications in photonics, including semiconductor lasers, photodiodes, and LEDs. Emerging uses such as VCSELs for 3D face recognition signal a market expansion. As the production of GaAs devices intensifies, the need arises for smaller devices and increased chip yield within wafers.

A viable solution for back-end processing of these wafers is plasma scribing technology using ICP etching equipment. While diamond scribing and blade dicing are common methods for wafer singulation, their wider scribing line widths (ranging from 50 μm to 100 μm) limit chip production, resulting in device defects and diminished yields. Plasma scribing, however, facilitates the processing of narrow scribe lines without substrate chipping.



(a) Blade scribing



(b) Plasma scribing

Plasma scribing processes all lines simultaneously

Figure 1. Comparison of Blade Scribing (a) and Plasma Scribing (b)

Plasma Scribing

Various methods are employed to segment wafers into chips, such as laser scribing and breaking, blade and laser dicing, and a combination of these methods. As wafer thickness diminishes, a method known as DBG (Dicing Before Grinding) —where half dicing precedes backside grinding— has been proposed to mitigate the risk of transporting thin wafers.

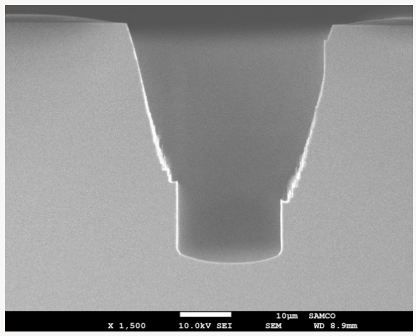
Plasma scribing circumvents mechanical contact like blade scribing, hence avoiding chipping or cracking. Moreover, unlike mechanical dicing, where the blade continuously scribes the wafer and the scribing duration elongates with decreasing chip size and longer lines, plasma scribing is all done at once regardless of chip size. Notably, GaAs wafers, due to their material properties, tend to chip, thus necessitating slower blade speeds compared to Si. Plasma scribing, however, remains unaffected by chip size or shape as wafers are processed in batches, reducing processing time in some cases. Furthermore, employing a dry process mask allows scribing line widths to narrow to 50 μm or less. Nevertheless, deep scribing demands a specific aperture width.

Since the 2010s, we have proposed plasma scribing as a deep scribing technique for compound semiconductors like GaAs. This report showcases the promising outcomes of plasma scribing on ø3-inch GaAs wafers using the ICP etching system RIE-400iP and evaluates breaks post-scribing.

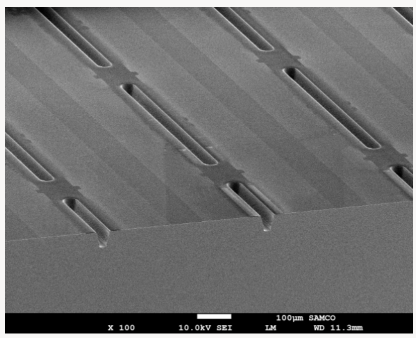
Process Data

The process involving scribing a GaAs wafer using ICP etching aims to create grooves several tens of micrometers deep using either a resist or SiO2 mask, necessitating high-rate and high-selectivity etching. This study focused on plasma scribing ø3-inch GaAs wafers utilizing our ICP etching system, RIE-400iP.

The SEM images in Figure 2 reveal the outcomes following plasma scribing. Due to the initial oblique mask shape, the aperture width at the process's top is wider than the mask pattern width, due to mask retraction. However, the shape is achieved without any problem for scribing applications. The etching rate is 1.57 μm/min, and a uniform depth of 47.2 μm was achieved across the entire surface of the ø3-inch wafer.



(a) Cross-section



(b) Bird's eye view

Figure 2. SEM images post-plasma scribing

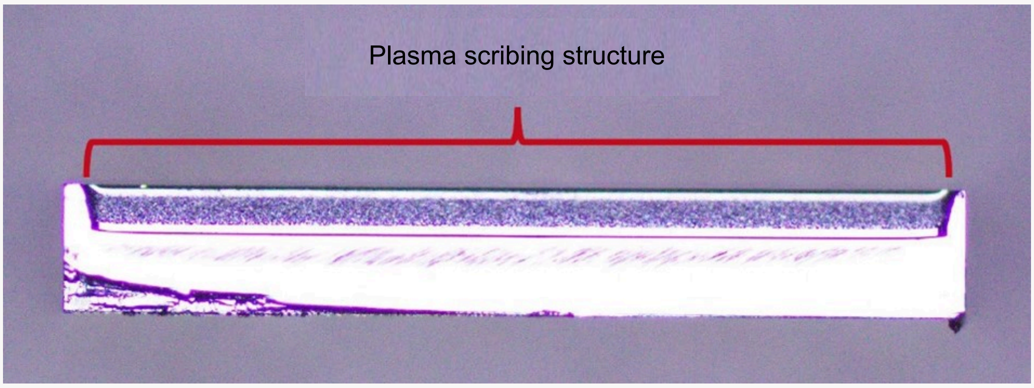


Figure 3. Cross-section analysis of the chip post-breakage

Following scribing, the chip's break quality was assessed. Figure 3 presents a cross-sectional image post-breakage. No lateral blurring of the break position was evident, and the chips separated cleanly from the center of the scribe groove, indicating consistent division across the entire wafer. Moreover, unlike laser processing, no debris adhered to the wafer surface, maintaining an excellent surface condition.

ICP Etching Systems

This study utilized the RIE-400iP ICP etching system for plasma scribing, specifically tailored to process compound semiconductors used in semiconductor lasers. The RIE-400iP system is specialized for ø2, ø3, and ø4-inch wafer processes, and excels in managing compound semiconductors like InP, GaN, and GaAs. Featuring the cutting-edge ICP source HSTC™ (Hyper Symmetrical Tornado Coil), it ensures consistent generation of stable, high-density plasma. Additionally, its optimized pumping structure guarantees efficient performance and minimizes the redeposition of by-products. The product range includes the load-lock RIE-400iP for R&D and the cassette loading RIE-400iPC for mass production, both compactly designed for space-efficient installation. As the exclusive provider of dedicated ICP etch systems for compound semiconductors ø4 inches or smaller, our unique process recipes, exceptional service, and support have earned high praise from customers worldwide.

Figure 4. Loadlock RIE system
RIE-400iP for R&D

Conclusion

This report showcases the results of plasma scribing on GaAs wafers and evaluates the post-scribing breakage. Plasma scribing holds significant potential to reduce both process time and manpower compared to conventional blade scribing methods. We have proposed an ICP etching system tailored for GaAs wafer scribing, specifically designed for compound semiconductors. Given the anticipated rise in miniaturization and production volume within the compound semiconductor field, the adoption of plasma scribing is highly likely. This report details the utilization of the RIE-400iP ICP etching system for small-diameter wafers. In addition to the RIE-400 series, the RIE-800iP series is designed for larger sizes such ø6-inch and ø8-inch wafers. Our comprehensive equipment range spans from small-diameter to ø8-inch wafers, catering to both R&D and mass production needs. Our commitment remains unwavering towards advancing process development as leading manufacturers of plasma systems for compound semiconductors.

Figure 5. Cassette loading RIE system
RIE-400iPC for mass production

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