Emerging Standardization for Sapphire Substrate Inspection

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KLA-Tencor
Accelerating Yield

A growing demand for GaAs substrates and epitaxial wafers is being driven by two major device industries: (1) LED devices used in automobiles, signs, and flat-panel displays, and (2) MMIC devices for mobile electronics and Wi-Fi stations. As a result, industry experts are forecasting 16% CAGR for GaAs material by volume over the next 5 years. While volume demand for GaAs materials will continue at a healthy pace, overall demand will be counterbalanced by decreasing die sizes as GaAs device manufacturers improve fabrication processes. To date the use of automated defect inspection has been much less pervasive in compound semiconductor processing than in silicon wafer processing, however this is changing with the increasing need to increase yield and reduce costs.

With tighter design limits, substrate and epi defectivity is more critical than ever. A number of global manufacturing facilities are employing an Optical Surface Analysis (OSA) inspection technique that combines the power of scatterometry, ellipsometry, reflectometry, and topographical analysis to detect and classify defects in substrates, epi-layers, and process films. OSA technology is being used by industry leaders to monitor production lines, identify mission critical defects of interest, and create process-specific recipes to detect and classify yield killing defects while ignoring nuisance defects.

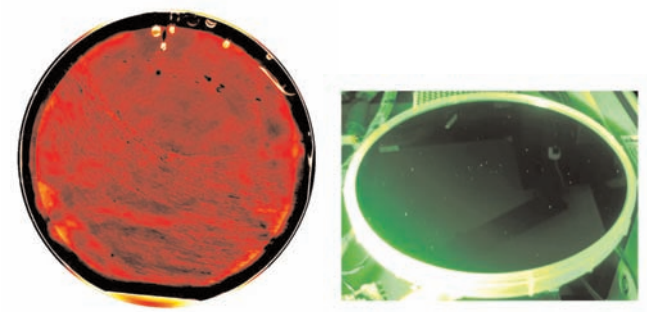

Figure 1: Candela Qphase™ image of GaAs substrate stains showing various water stains, wipe stains, edge defects and dark spots. Stains have been identified as killer defects resulting in rough epi morphology and poor epi-layer adhesion. Substrate stains cannot be seen under microscope or bright light inspection

Substrate stains on bare GaAs wafers are one such killer defect and frequently result in full wafers scraps after epi deposition. Historically GaAs substrates have been monitored with optical microscope or bright light inspection. However these inspection techniques are ineffective at detecting these killer stains and other thin film defects like some CMP residues. Many of these stains are only tens of angstroms thick and are not detectable with microscope or bright light inspection.

Figure 1 shows the OSA Qphase™ (digital image analysis application) image of GaAs substrate stains highlighting various water stains, wipe stains, edge defects and dark spots. Certain stains have been identified as killer defects resulting in rough epi morphology and poor epi-layer adhesion. Failed epi is causing full-wafer scraps throughout the supply chain creating turmoil between substrate suppliers, epi OEMs and device manufacturers as incumbents investigate whether the resultant wafer scraps are due to growth conditions or substrate quality. The Candela OSA has proven effective at root cause analysis of GaAs substrate stains and real-time defect detection and classification.

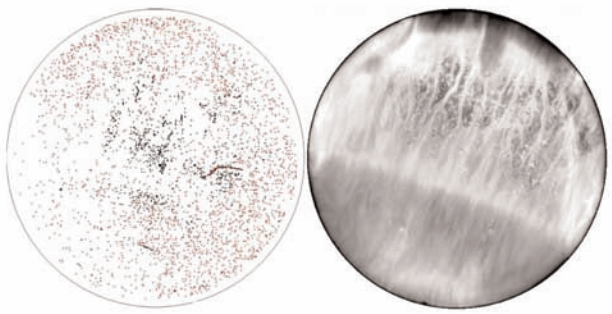

Figure 2: OSA Defect Map and Qphase™ image of same bare silicon wafer

The long-standing industry standard in the semiconductor industry has been the report of Light Point Defects (LPDs) and surface haze. LPD defect maps are commonly used for process control and tool monitoring but a growing number of manufacturers are recognizing that some killer defects do not necessarily scatter light and scatterometry alone is not enough to meet their quality control needs. Figure 2 shows an LPD defect map and OSA Qphase image of the same bare silicon wafer. The substrate stains seen in the Qphase image are not detected using scatterometry.

Optical surface analysis technology enables manufacturers and suppliers to automate defect inspection and define well-controlled process control limits. OSA technology, as found in KLA-Tencor's Candela™ CS20, can be employed at incoming substrate inspection, post-clean inspection, and after epitaxial growth and process film deposition to improve yield.

To learn more, read about the Candela CS20 at:
www.kla-tencor.com/CS20