From Full-Field to Single-Spot: Laser-Based Processing for Microelectronics

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The increasing complexity and miniaturization of semiconductor devices require innovative manufacturing solutions that deliver both high precision and thermal efficiency. This presentation examines a variety of laser processes for microelectronics, from full-field to single-spot processing, enabling next-generation microelectronics and encompassing applications from advanced diagnostics to power device and sensor fabrication.

By employing ultrafast lasers, systems such as 3D-Micromac's microPREP® achieve high-speed, athermal material ablation with micrometer-level accuracy (Fig. 1), significantly reducing preparation times from hours to minutes for complex semiconductor packages. Therefore, laser-based sample preparation is a versatile solution for failure analysis and quality control.

As an example of well-established processes in device fabrication, laser-based Ohmic contact formation (OCF) for Silicon Carbide (SiC) wafers is examined. Unlike traditional full-field thermal processing, localized UV-laser annealing delivers the precise energy density necessary for nickel silicide formation while minimizing global substrate heating (Fig. 1). This approach is essential for 3D integration and for maintaining the integrity of thin wafers especially in the field of power electronic device applications.

With selective laser-annealing, precision can be further enhanced. This technique is particularly suited for pinning magnetic reference layers in GMR and TMR (magnetoresistive) sensors. This targeted approach improves sensor performance and reliability while supporting sustainability by achieving substantial energy savings compared to global heating techniques.

Additionally, Laser-Lift-Off (LLO) and Laser-Induced-Forward-Transfer (LIFT) processes are discussed. These techniques illustrate the versatility of laser tools, enabling both pinpoint accuracy at the scale of microLEDs and large-area separation of functional layers, such as metal films, with high throughput.

The limits of miniaturization are extended through high-precision processing of electronic components at the 1-2 µm scale. Advanced systems such as 3D-Micromac's microVEGA FC facilitate the precise separation of individual fuses and electrical connections, combining exceptional accuracy with industrial-grade productivity.

In summary, laser-based processing provides a scalable, sustainable, and highly precise alternative to conventional thermal methods. Transitioning from large-scale treatments to targeted single-spot interventions, these technologies advance the development of high-performance microelectronics and next-generation power systems..

References
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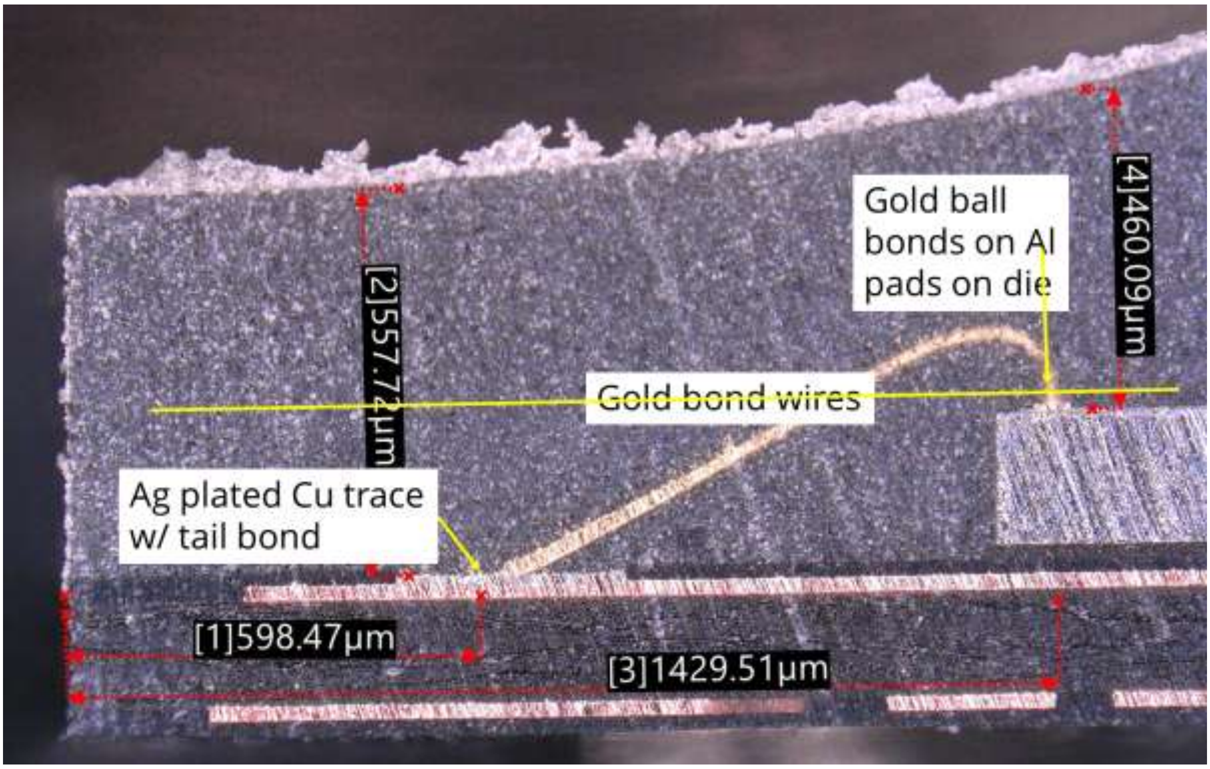

Figure 1: View of iBGA package-cross section prepared with ultrashort pulsed laser

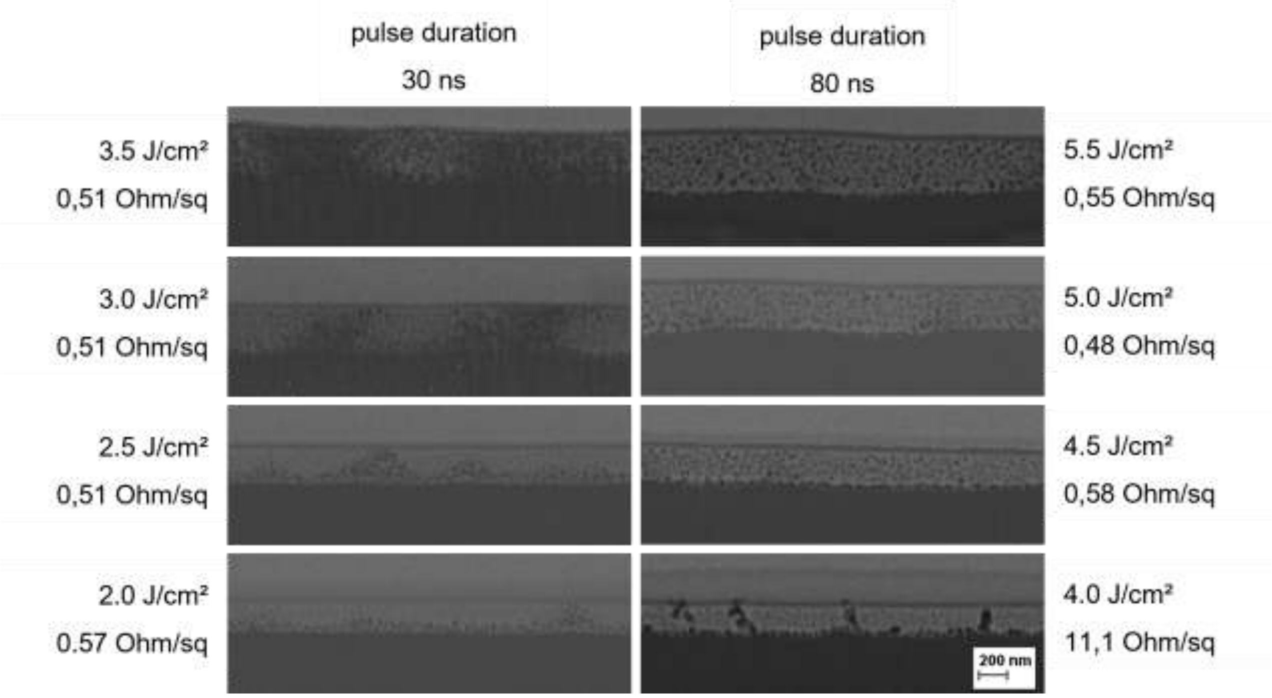

Figure 2: Comparison of Ni_xSi_y interface formed by shorter pulsed laser and longer pulsed laser