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## Scanning Acoustic GHz-Microscopy in Microelectronics Failure Analysis

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The ongoing trend in microelectronics aims at increasing functionality while reducing the devices footprint. This leads to the currently highly pursued approach of three-dimensional integration of individual devices with e.g. sensors and application specific integrated circuitry resulting in highly integrated and complex systems. By extending the system structure to the third spatial dimension, the aim of chip-to-wafer or wafer-to-wafer bonding techniques is no longer restricted to mechanical integration only. Techniques like adhesive bonding, Cu/Cu thermo-compression bonding or hybrid bonding have also to provide a precise formation of robust and reliable vertical electrical interconnects within the bonding interface. Furthermore, the interaction of Through-Silicon-Via technology (TSV) that enables an efficient 3D-distribution concept with the bonding technologies have to be taken into account. As a consequence, these new technological concepts lead to new defect risks which require novel and adapted inspection methods for assessing quality-related properties and understanding the physical relationship.

Today scanning acoustic microscopy (SAM) is already widely used in quality control and failure analysis applications within microelectronics development and manufacturing. The technique is particularly sensitive to material boundaries for the assessment of quality- and reliability- affecting factors like voids and inclusions, cracks, delamination, bonding defects, and many more [1]. Since 3D-integration technologies result in reduced spatial dimensions of the electrical and mechanical interconnects and, thus smaller defects, the demand on the resolution capabilities of potential inspection techniques increases. The successful application of SAM in 3D integration however, requires overcoming limitations in the achievable spatial resolution and the integration of adapted SAM analysis technologies for vertical contacts.

The current paper presents the relatively novel approach of applying acoustic microscopy in the GHz-frequency band to increase the achievable lateral resolution and the sensitivity to surface and near-surface features with resolutions in the 1  $\mu\text{m}$  regime. The potential of the GHz-SAM approach will be illustrated describing the inspection of Cu-Cu interfaces in mono-metallic wire bond systems [2] and the detection and propagation-assessment of stress induced voids in thick Al-power lines for high-temperature applications. Using short focal-length transducers GHz-SAM was also applied for the detection of delaminations in sub-surface electrical lines and the detection of cracks in the passivation layer of an RFID chip and the cracks sub-surface propagation. Finally, preliminary results of on-going research addressing the inspection of Through-Silicon-Vias will be presented and discussed.

### References:

1. Brand S, Tismer S, Moe ST, Schjolberg-Henriksen K, "Non-destructive wafer-level bond defect identification by scanning acoustic microscopy", *Microsyst Technol.*, 1385-1394, 2015
2. Vogg G, Heidmann T, Brand S (2015) „Scanning acoustic GHz-microscopy versus conventional SAM for advanced assessment of ball bond and metal interfaces in microelectronic devices“, *Microelectronics Reliability* 55(10), 1554-1558, 2015.