

Low Temperature Fusion Wafer Bonding for Wafer-Level 3D Integration Applications

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During the past decade the need for high levels of integration stimulated the development of tridimensional (3D) architectures.

The new applications required development of new processing techniques besides the standard CMOS technology and wafer bonding processes were proven to be suitable for fabrication of wafer-level 3D architectures.

Initially used for substrates manufacturing (e.g. Silicon-on-Insulator – SOI) or relatively simple Micro-Electro-Mechanical Systems (MEMS) devices, wafer bonding is nowadays capable to handle fully processed wafers with high wafer-to-wafer alignment accuracies.

Due to the high process temperature required for fusion bonding (e.g. $\sim 1000^{\circ}\text{C}$) this process was not very attractive for 3D applications. In the recent years low temperature fusion bonding processes were developed for addressing such applications: in such process the maximum temperature ranges typically between 200°C – 400°C .

Fusion bonding process consists of two steps: in first step wafers are placed in contact at room temperature resulting in the primary (weak) adhesion of the two surfaces while the second step (thermal annealing) is responsible for strengthening the bond by transforming the interface bonds into covalent.

A low temperature fusion bonding process based on plasma activation of surfaces prior bonding was developed. The results obtained during process characterization could not be explained by the known bonding mechanism for silicon fusion bonding (reported in literature). The investigations lead to development of a new model, which will be introduced. The process condition is compatible with the high cleanliness levels required by CMOS technology and can be used for various application scenarios involving Through-Silicon Vias (TSV) technology.

Two types of applications will be presented here: wafer stacking for backside illuminated (BSI) CMOS image sensors and bonding of thin wafers for TSV-based applications. The application for thin wafers bonding uses the low temperature fusion bonding process for creating a permanent bond but employs additionally a temporary bonding process based on polymer adhesives. Experimental results will be presented in order to illustrate the challenges raised by such applications as well as the benefits of using plasma activated fusion bonding technology.