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3D Integration Technology for Pixel Detector and Image Sensor using 3-μmφ Au Cone Bump Junctions

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Abstract

A 3D IC is an effective solution for reducing the manufacturing costs of advanced 2D LSI while ensuring equivalent device performance and functionalities. This technology allows a new device architecture of stacked detectors/sensor devices with a small dead sensor area and facilitates hyper-parallel data processing. In pixel detectors or image sensor devices, many transistors are required to be accommodated per pixel area without increasing the pixel size. Consequently, many methods to realize 3D-LSI devices have been developed to meet this requirement by focusing on the unit processes of 3D-IC technology: (1) through-silicon via (TSV) formation and (2) bonding electrically and mechanically between tiers of the stack. The bonding process consists of several unit processes such as bump or metal contact formation, chip/wafer alignment, chip/wafer bonding, and underfill formation, and many combinations of the processes have been reported. Our research focuses on the bonding technology with the objective of realizing a versatile bonding technology for silicon LSI devices, compound semiconductor devices, and MEMS devices at temperatures less than 200 °C for heterogeneous integration. The gold cone bump formed by the NpD (nanoparticle deposition) method is one of the promising candidates for this purpose.

This paper presents the experimental results of the prototype pixel detector with 3-μmφ gold cone bump connections with adhesive injection. The as-deposited cone bump consists of gold nanoparticles and is easier to deform compared to plating gold. Consequently, the collapsibility of the gold cone bump allows for low-stress bonding, resulting in a compliant and reliable junction. The bump size is determined by photoresist patterning, and the bump connection does not protrude largely during junction formation, in contrast with the melting type bump connections. In addition, the shrink ratio of the volume is larger than that of the surface area. So the bump resistance of an easily oxidized metal with a diameter of few microns is affected by the bonding atmosphere. On the other hand, gold is an oxidation-resistive material; therefore, bonding with a micro gold cone bump does not adversely affect the electrical characteristics. Figure 1 shows a 3-μmφ gold cone bump array, while Figure 2 shows the bump resistance of the daisy chain TEG. The resistance per bump is approximately 6 Ω.

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