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# 3 Dimensional Stacked Pixel Detector and Sensor Technology Using less than 3-μmφ Robust Bump Junctions (12' + 3')

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A 3D-IC (Three Dimensional Integrated Circuit) is an effective solution for reducing the manufacturing costs of advanced 2D LSI while ensuring equivalent device performance and functionalities. This technology allows for a new device architecture of stacked detectors/sensor devices with a small dead sensor area and facilitates hyper-parallel data processing. In pixel detectors, many transistors must be accommodated per pixel area to improve the space and time resolutions without increasing the pixel size. Consequently, many methods of realizing 3D-IC 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) electrical and mechanical bonding 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 these processes have been reported. Our research focuses on fine pitch bonding technology with the objective of realizing a versatile bonding for silicon LSI devices and compound semiconductor devices at temperatures less than 150 ⊠C for preventing device degradation. Gold microbump connections realized by solid-phase diffusion are one of the promising candidates for this purpose. This paper presents experimental results for a prototype pixel detector with 3.0-μmφ gold cone bumps fabricated by NpD (nanoparticle deposition) and that with gold cylindrical bumps fabricated by a low-incident-angle deposition method. The as-deposited cone bumps consist of gold nanoparticles and are easier to deform compared to the plated gold bumps. Consequently, the collapsibility of the gold cone bumps allows for low-stress bonding, resulting in a compliant and reliable junction without damaging the device surface. The bump size is determined by photoresist patterning, and the bump connection does not greatly protrude during junction formation, in contrast with melting-type bump connections. In addition, the shrinkage ratio of the volume is larger than that of the surface area. Thus, 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 gold cone microbumps does not adversely affect the electrical characteristics. The resistances per bump of the stacked Si-base pixel detector and stacked CdTe/Si-LSI X-ray sensor are both approximately 0.25 Ω.

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