Research and Technology Advances of 3D IC

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The significance of 3D IC has made impacts on current advanced electronic devices and systems, especially for high-performance computing (HPC) and AI applications. Since 3D IC can use either a monolithic approach or stacking technology to integrate multiple layers vertically, in addition to adding more device layers, this integration format and platform provide flexibility to various substrates, functions, and products. More specifically, 3D IC can fulfill both homogeneous and heterogeneous needs based on system and product requirements, while maintaining a small form factor and adhering to low power consumption guidelines. To meet the various requirements in semiconductor device and system integration, 3D IC development has also expanded from BEOL 3D to FEOL 3D. The refinement of vertical interconnection pitch and size, as well as exploration of solutions to mitigate stress and warpage issues, will provide a more reliable solution to the next generation of semiconductor device and electronic system integration.

Three research and technology advances will be introduced in this presentation. First, to address the objectives and achieve high-performance computing and compact dimensions, fine pitch and dimensional interconnects are essential for stacking vertically, which necessitates the demand for Cu hybrid bonding. Particularly, low bonding temperature is definitely beneficial to avoid high stress and warpage issues. Low-temperature Cu hybrid bonding using passivation technology can fulfill these goals. The second technology aims to achieve a low cost and low warpage RDL interposer, namely HRDL. HRDL is established through low-temperature Cu/polymer hybrid bonding using passivation technology. This platform can effectively minimize total warpage by bonding two stacked RDL layers. Finally, laser recrystallization and liquid-epitaxial Si/Ge for ultra-thin device stacking as next-generation roadmap technology will be introduced. This monolithic 3D IC technology can provide a high-density and ultra-thin layer stacking platform. This presentation will delve into the challenges associated with these advances and discuss future directions.