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ABSTRACT:

Bond Wave Modeling and Interface Strength Characterization in W2W/D2W Stacks

Three-dimensional integration is becoming increasingly important as transistor scaling approaches its practical limits and new routes are needed to sustain improvements in power, performance, and system density. Direct die-to-wafer and wafer-to-wafer hybrid bonding are among the most promising technologies in this context, enabling the stacking of wafers or dies at room temperature through Van der Waals attraction between clean dielectric surfaces.

Despite its advantages, hybrid bonding remains highly sensitive to the mechanical response of wafers during the bonding sequence. Die or wafer deformation can introduce overlay errors and local distortions that reduce process yield. These effects are governed by the combined influence of bonding tool design, residual stress, wafer warpage, and interfacial adhesion. Because purely experimental optimization of these parameters is expensive and time-consuming, numerical simulation offers an efficient route to investigating bonding dynamics and clarifying the mechanisms responsible for deformation. This talk will present simulation-based insights into wafer-scale deformation during bonding, as well as thermomechanical stress and strain analyses at the nanoscale.

In addition to deformation control, accurate quantification of bond strength is essential for hybrid bonding process development. Interface adhesion is influenced by surface morphology, material chemistry, and post-bonding thermal treatments, all of which affect the reliability of the final bonded structure. The talk will therefore review and compare different techniques for determining the adhesion energy of hybrid-bonded wafers, using silicon carbon nitride, SiCN, as the main bonding dielectric.