ABSTRACT:

Preserving the Stress State: Nondestructive X-Ray Microscopy for 3D Interconnect Stack Reliability

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Advanced packaging technologies introduce complex thermo-mechanical stress states that accelerate degradation kinetics in Cu interconnect stacks. CTE mismatch, chip-package interaction, and assembly-induced loading act as additional driving forces for microcrack initiation and propagation in BEoL structures beyond conventional planar devices.
Finite element modelling of Si thinning shows a significant influence on the mechanical stress state in the BEoL stack, supporting the need nondestructive studies on unthinned dies and 3D-stacked systems. X-ray microscopy and nano X-ray computed tomography (nano-XCT) at photon energies exceeding 10 keV are unique techniques to fulfill this need.
Laboratory high-resolution X-ray imaging is applied to study microcrack propagation in BEoL Cu/low-k structures under in-situ mechanical loading, yielding crack morphology, crack opening displacement, and interface delamination geometry at sub-100 nm resolution [1] - without destructive sample preparation. A nano-XCT study at 24 keV photon energy confirms the capability of truly nondestructive high-resolution X-ray imaging of $Cu/Cu_6Sn_5/Cu$ microbump interconnects [2].

[1] K. Kutukova, J. Gluch, M. Kraatz, A. Clausner, E. Zschech, Materials & Design, 221, 110946 (2021).
[2] B. Lechowski, K. Kutukova, J. Grenzer, I. Panchenko, P. Krüger, A. Clausner, E. Zschech, Nanomaterials 14, 233 (2024).