Title: **High-Resolution 3D X-ray inspection of advanced packaging semiconductor devices**

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Advanced semiconductor packaging and heterogeneous integration are enabling major gains in system performance, bandwidth, and form factor, but they also introduce increasingly complex three-dimensional interconnect structures that are difficult to inspect nondestructively. High-resolution 3D X-ray imaging provides a powerful approach to visualise the structure and defects in such devices without requiring optical access. This presentation gives an overview of 3D X-ray inspection methods for inspection of electronics and semiconductor devices demonstrates the capabilities of X-ray nano-CT and laminography.

Case studies include (i) the inspection of high-bandwidth memory (HBM) microbumps (Fig. 1A), where 3D imaging can reveal interconnect geometry and potential reliability-relevant features, (2) hybrid bonding structures (Fig. 1B), where high spatial resolution is needed to assess interfaces and fine-pitch connections, and (3) through-silicon vias (TSVs, Fig. 1C), where volumetric inspection helps visualize internal structures and defects that are not accessible otherwise. Together, these examples demonstrate how X-ray imaging can support process development, failure analysis, and reliability assessment across different device architectures.

While nano-CT is well suited for small samples where high-resolution volumetric imaging from many projection angles is possible, laminography offers advantages for larger planar samples where the conventional CT geometry is not practical. By comparing these approaches across multiple application examples, the presentation highlights how the choice of imaging method depends on sample geometry, resolution requirements, field of view, and the inspection question.

Overall, high-resolution 3D X-ray imaging is an important nondestructive tool for understanding and qualifying the increasingly complex structures used in advanced semiconductor packaging. By providing volumetric information on buried interconnects, interfaces, voids, cracks, misalignments, and other process- or reliability-relevant features, it helps bridge the gap between external inspection and destructive physical analysis. 3D X-ray imaging therefore offers complementary capabilities for process development, failure analysis, and reliability assessment in electronics and semiconductor devices.

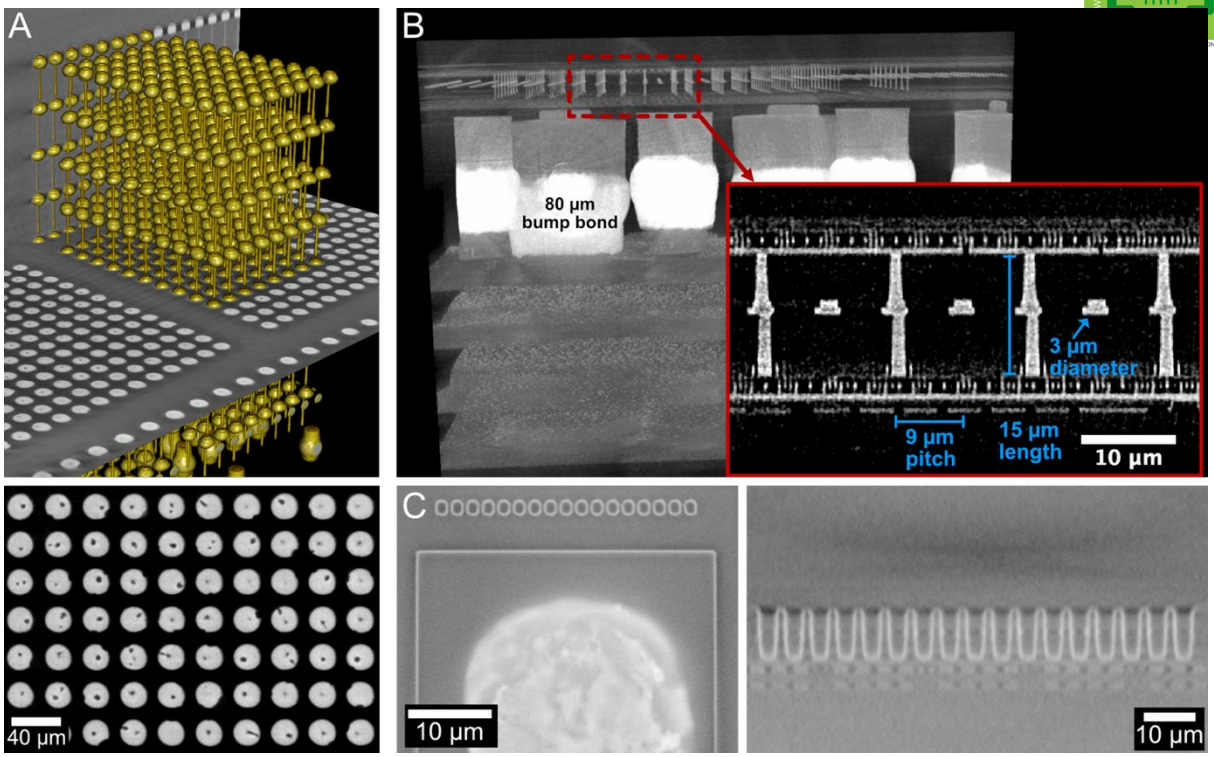

Figure 1: 3D X-ray imaging of (A) 20 µm microbumps in an 8-layer HBM stack, (B) 9 µm pitch hybrid bonding connecting a CPU core to its VCache memory in an AMD Ryzen 7 5800X3D processor, and (C) 4 µm diameter TSVs in a CMOS camera sensor from a Samsung Galaxy S21 Ultra.

Bio:
Till Dreier is an Application Scientist at Excillum AB, specializing in X-ray imaging and computed tomography for industrial and scientific applications. He holds a Ph.D. in Medical Radiation Physics from Lund University, specializing in high-resolution X-ray CT and phase-contrast imaging and an M.Sc. from Mid Sweden University in Electronics Engineering. Till works at the intersection of research and industry, supporting the adoption of advanced X-ray source technologies in materials science, semiconductors and electronics, battery research and production, and nondestructive testing.