Site-specific analysis for nanoelectronics using hybrid SPM-TEM metrology

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With the introduction of 3D devices and stackable architectures in both logic and memory applications, the physical characterization of 3D nano-sized volumes is becoming of paramount importance. Furthermore, for specific applications the characterization cannot be limited to the observation but it has to incorporate the electrical properties of the sample. Therefore, the main requirements for a valuable 3D characterization technique are: (1) nano-scale sensitivity for morphological and electrical features and (2) capability to expand from 2D (surface analysis) towards probing in the three dimensions. Here, scanning probe microscopy (SPM) tomography (often referred to as Scalpel SPM) is proposed as an approach for three-dimensional characterization of confined volumes. After introducing the fundamentals of high-pressure tip-induced material removal, the controlled sub-nm slice-and-view capability is demonstrated for different materials leading to the characterization of highly confined volumes (< 1000 nm^3). This is applied here to various emerging devices including logic and memory with emphasis on the combination of TEM analysis with SPM.