Soft X-Ray: Novel metrology for 3D profilometry and device pitch overlay

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Due to their increasingly complex 3D geometries, upcoming gate all around (GAA) devices pose new metrology challenges for which there is not yet any established HVM metrology solution, in particular for various critical timed etch steps [1]. Soft x-ray (SXR) scatterometry using 10-20 nm wavelength light is a promising next-generation metrology technique for 3D profile metrology and overlay (OVL) applications. This wavelength regime offers unique benefits over existing metrology techniques today:

(1) Short wavelengths allow for higher resolution measurements than traditional visible wavelengths could offer, enabling measurement of structures at device pitches.

(2) Primarily single scattering yields low correlation between parameters and aids physical interpretation of signals. This enables many parameters of interest to be extracted accurately and simultaneously.

(3) SXR provides 3D capability, with stack heights up to 400 nm supported and high depth resolution due to the broadband source and sensor.

These properties together make SXR suitable for measuring the 3D profiles of advanced devices such as gate all around (GAA) transistors, as well as after develop (ADI) overlay at device pitch.

In this presentation [2], we demonstrate SXR for profile metrology of GAA devices. We show sensitivity to average SiGe lateral recess etch depth as well as individual nanosheet critical dimensions, which cannot be reliably accessed by other non-destructive, inline metrology techniques available today. We furthermore demonstrate sensitivity in ADI OVL measurements directly on device-pitch structures in the presence of an underlying patterned nuisance layer.

[1] M. A. Breton, D. Schmidt, A. Greene, J. Frougier, N. Felix, "Review of nanosheet metrology opportunities for technology readiness," J. Micro/Nanopattern. Mats. Metro. 21(2) 021206 (18 April 2022) https://doi.org/10.1117/1.JMM.21.2.021206

[2] C. Porter *et al.*, "Soft x-ray: novel metrology for 3D profilometry and device pitch overlay," Proc. SPIE 12496, Metrology, Inspection, and Process Control XXXVII, 124961I (27 April 2023); https://doi.org/10.1117/12.2658495