Challenges in Metrology for the Semiconductor Industry

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Leading edge Ultra Large Scale Integrated Circuit manufacture is now well into the realm of ***Nanoelectronics***, with some critical dimensions below 40 nm. The pressures on metrology supporting this manufacture are escalating rapidly. In this presentation we will discuss present and future metrology needs and potential solutions.

Critical Dimensional metrology involves precise and accurate measurements of defined features on the surface of the semiconductor wafer. The measurements include linewidth, feature height and shape, line and wall edge roughness, line width irregularity, and hole diameter, shape and profile. One potential solution is Small Angle X-ray Scattering. Progress on the development of this technique will be described.

Film thickness, flatness, electrical and compositional properties must be measured accurately to assure circuit performance. Two- and three dimensional characterization of ultra-shallow semiconductor junctions, physical, compositional and electrical characterization of thin, often strained, semiconductor layers are new measurement needs as the industry moves from traditional CMOS technology to the advanced structures such as FINFETs, partially and fully depleted CMOS, and even more exotic structures. Advances in probe techniques as well as the traditional optical, X-ray, and mass spectrometric techniques will be summarized.

Detection and compositional analysis of particulates press existing techniques to their limits as dimensions shrink. One potential solution being explored is the use of an energy-dispersive spectrometer based on a superconducting transition-edge microcalorimeter sensor with an energy resolution 40 times better than conventional instruments. Progress in the development of cluster SIMS may greatly improve the ability to detect organic contamination on semiconductor surfaces

The rapid introduction of new material systems, such as copper and low-k materials for interconnect, high-k dielectrics and metal conductors for gate stacks demands careful reexamination of the metrology techniques to assure reliability.

Finally, addressing the critical metrology issues facing the industries supporting the semiconductor manufacturing industry is essential. Examples include the characterization of the optical materials used in advanced lithography, both in the deep ultraviolet and the extreme ultraviolet spectral regions, detection and calibration of detection equipment for trace impurities in process gases, calibration of mass flow controllers for highly reactive process gases, and development of new techniques for circuit testing at extremely high frequencies.