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Application of Neutron Measurements to Advance Semiconductor Manufacturing: Next-Generation Lithography and Nanoporous Thin Films

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As feature sizes in microelectronic devices continue to decrease to sub-32 nm dimensions, new measurement methods are needed to understand the physical phenomena used in state-of-the-art lithography methods that may limit their fabrication and probe the structure and properties of new electronics materials. Neutron (and x-ray) beams have emerged as powerful probes of new manufactured structures with characteristic length scales ranging from (1 to 100) nm in thin films and in the bulk. In particular, X-ray reflectivity (XR), neutron reflectivity (NR), small angle neutron scattering (SANS), and small angle X-ray scattering (SAXS) can be applied in novel ways to address fundamental issues important to the microelectronics industry. This talk with highlight the application of neutron and x-ray measurement methods to investigate important problems in the development of photoresist materials used in lithography and of nanoporous low-dielectric-constant materials needed for next generation integrated circuits. Specific topics include: 1) the direct measurement of the reaction-diffusion front with nanometer resolution from ideal line-edges to probe image blur and roughness from photoacid diffusion 2) identification and measurement of a "residual swelling fraction" during the development and 3) measurements of the pore structure of low-dielectric constant thin films. Insights from these studies can provide guidelines and opportunities for the further extension of photoresist technology into the future and the integration of new materials into integrated circuits.