Nanoparticle Modified Developers for Enhanced Dissolution Control Studied by Simultaneous Light Reflectance and Quartz Crystal Microbalance Techniques

M.F. Roll, V.M. Prabhu
National Institute of Standards and Technology, Materials Measurement Laboratory, Polymer Division. Gaithersburg, MD 20899
mark.roll@nist.gov

Polyelectrolyte swelling and dissolution is a fundamental process in many important applications including drug delivery, pH-functional materials, and photolithographic development. This behavior is characterized by changes in chemical composition, which are reflected by significant changes in optical and mechanical properties, and we will demonstrate a unified instrumental approach to investigate these changes. Optical characterization will be accomplished by thin-film reflectometry, using well-defined relationships between composition and refractive index. Mechanical characterization will be accomplished by simultaneously interrogating the thin-film with a quartz-crystal microbalance. A consistent matrix description of these wave propagation problems will be used to fit the experimental data, an optical spectrum and resonant frequency and impedance taken at 50 millisecond intervals.

In particular, we will use this system to characterize differences in the dissolution of polyhydroxystyrene thin-films by tetramethylammonium hydroxide (TMAOH) and lithium hydroxide solutions in comparison to these solutions with dissolved silicate nanoparticles. Such silicate solutions are well-studied, and the dominant anionic species is the high molecular weight, cubic octa-anion at high concentrations. We propose that such an alkaline species would diffuse significantly more slowly into the dissolving polymer, allowing for an additional control over the dissolution rate and dynamics. This control could, in principle, provide a route to minimize line-edge roughness in photolithographic development by reducing the degree of developer penetration into partially deprotected regions of the photoresist.

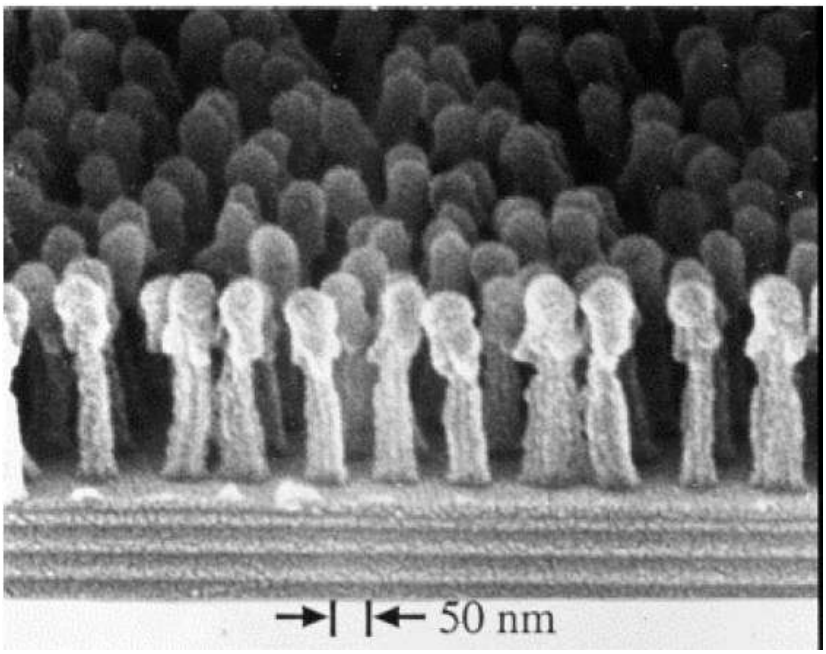

Figure 1: The Debutantes' Ball: At the debutantes' ball, young nano-women gather in their finery at the edge of the stage to weep because none of the nano-boys will not dance with them. The micrograph shows an array of 50 nm wide posts with a periodicity of 100 nm. The posts consist of PMMA on top of an antireflection coating. The substrate consists of a 250 nm thick layer of silicon nitride on silicon. Winner of the 1995 "Most Bizarre Micrograph" prize. Submitted by Tim Savas, Massachusetts Institute of Technology.