Direct measurement of the spatial extent of the *in situ* developed latent image by neutron reflectivity

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The dissolution of partially deprotected chemically amplified photoresists is the final step in printing lithographic features. Since this process step can be tuned independently from the design of the photoresist chemistry, measurements of the dissolution behavior of photoresists may provide needed insights towards improving line-edge roughness. The residual swelling fraction (RSF) is the remaining photoresist that swells rather than dissolves in a lithographically printed feature. The latent-image shape, photoresist chemistry and composition, photoacid concentration, nanoscale deprotection morphology, and aqueous hydroxide properties contribute to the RSF. One measurement challenge is quantifying the RSF spatial extent at the line-edge. Contrast variant neutron reflectivity was developed to quantify the nanometer-scale spatial distribution of resist and aqueous base developer near a developed model line edge. The magnitude of the spatial extent of the swelling measured during *in situ* development, rinse, and drying imply the resist profile at line-edge is dynamic on the nanometer scale. These direct measurements of the RSF stability are finally probed as a function of added monovalent (1:1) and divalent (1:2) salt additives. The depth profile results are combined with mass-sensitive quartz crystal microbalance measurements to understand the mechanical properties of the RSF. This general approach using 193 nm photoresist model materials is extendable to systems of alternative resist architectures for use in immersion and EUV lithography.