608h Quantification of the Reaction-Diffusion Front in Photoresist Thin Films

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Line edge roughness (LER) is a critical issue in lithographic device fabrication as feature critical dimensions (CD) continue to shrink. The fidelity of the observed LER and CD result from many factors in interdependent processing steps. These factors can be separated into two groups, those that control the dissolution process (i.e., developer concentration, photoresist/developer interaction, and molecular weight) and those that define the internal deprotection interface (i.e., image blur and acid diffusion). We use model 193 nm resist materials to systematically address both groups by quantifying relevant materials characteristics and isolating the effects of specific processing variables on LER. Here, we report the spatial evolution of the deprotection reaction using a bilayer geometry to represent the line-edge as a function of post-exposure bake (PEB) time using neutron reflectivity (NR) with nanometer resolution. The bilayer consists of an acid feeder layer, comprised of an aqueous base soluble polymer and photoacid generator (PAG), whereas the bottom layer is a reactive photoresist, poly(methyladamantylmethacrylate). After UV exposure, the bilayer is baked leading to acid diffusion and deprotection in the photoresist resulting in a broadened deprotection profile. The broadened compositional profile formed by the reaction-diffusion of the photoacid was determined through the loss of the hydrogen-rich methyleneadamantane protecting group, providing adequate neutron reflectivity contrast. Quantification of the deprotection and residual methyleneadamantane of the whole film from FTIR was used to deconvolute the neutron scattering length density profile into depth profiles of deprotection and methyleneadamantane content. Variation in PEB time and PAG as well as photoresist chemistry allows for the deprotection profile to be selectively tuned from sharp to broad. Development of these model bilayers with aqueous base allows for the influence of the deprotection profile shape on LER to be eluded though surface roughness analysis with atomic force microscopy (AFM).