Advances in neutron research methods for photoresists fundamentals

Vivek M. Prabhu, Shuhui Kang, Kristopher Lavery, Eric K. Lin, Wen-li Wu
Polymers Division, National Institute of Standards and Technology, 100 Bureau Dr, Gaithersburg, MD 20899

Sushil Satija
Center for Neutron Research, National Institute of Standards and Technology, 100 Bureau Dr, Gaithersburg, MD 20899

Photoresist polymer thin films are imaging layers for photolithography. These chemically amplified photoresists, however, are challenged to image sub-22 nm features with low line-edge roughness by high-throughput projection lithography. The root causes of the observed photoresist fidelity are separated into two groups, those that (I) define the internal deprotection interface (i.e., image blur and acid diffusion) and (II) control the dissolution process (i.e., resist composition, developer concentration, photoresist/developer interactions). Direct measurements that elucidate the mechanisms of the photoresist imaging and development are of interest to provide guidance for next-generation projection lithography materials and process strategies.

In close collaboration with industry, we have developed high resolution metrology tools, including specular neutron reflectivity and off-specular diffuse scattering, using beams of neutrons with wavelength 0.475 nm. By enhancing the optical contrast through deuterium substitution these methods probe buried polymer interfaces, such as the deprotection profile[1-3] in the latent image line-edge to the photoresist/developer interface[4] with nanometer resolution. Specific examples of the depth profile of the latent image and developed image in model 193 nm and EUV photoresists will be described.

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