The interface study of photoresist/underlayer using hybrid x-ray reflectivity and x-ray standing wave approach

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The photoresist (PR), a light-sensitive film, changes structure upon light exposure to create a patterned mask for etching nanostructures, including semiconductor device components. In this study, we used a prototype organic chemically amplified resist (CAR) for extreme ultraviolet lithography (EUVL). It consisted of a blend of a copolymer of poly(hydroxystyrene) modified with a 50% t-Butyloxycarbonyl protecting group and tert-butyl methacrylate blended with a photoacid generator (PAG) and a base quencher. The PAG in this PR contains sulphur (S).

This study was aimed to investigate PAG distribution across PR thickness and its migration towards the underlayer/substrate post-EUV exposure. Tracing of S in the PAG can be helpful in achieving these objectives. The X-ray standing wave (XSW) technique has been used to analyze PAG layer distribution on blanket PR and its modification after exposure to EUV light. Modulated S fluorescence in XSW movement reveals S distribution within the film depth, while X-ray reflectivity data complements this analysis by providing electron density profiles of the films.

Multiple PR samples on Si substrate were prepared, with two pieces each for study. One piece was exposed to EUV radiation, while the other remained unexposed. Analysing these samples with X-rays is challenging due to i) low contrast in the PR layers and underlayer, ii) the possible low stability PR during the X-ray experiment. We've experimentally shown that irradiating the PR layer with monochromated laboratory Cukα radiation for 24 hours doesn't alter the measurement data significantly. However, we observed measurable modifications in the internal underlayer and PR structure when analysing XSW and XRR data. This suggests that EUV exposure causes PR layer shrinkage, possibly interface roughening and redistribution of S within the PR layer. We will present the obtained results, discuss the tolerances of analysis and benefits of additional complimentary measurements.