Study of material modifications produced by a HBr treatment applied to 193nm resist chemistries

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The decrease in the resist film budget implies a better etch resistance to use single layer 193nm photoresists for the 65nm node and beyond. It is known that a HBr treatment, usually referred as a curing step, significantly improves the resist etch resistance. The chemical and physical modifications induced in the resist by this treatment have been studied[1,2] but are not fully understood.

Therefore in this paper we report a study on the physical and chemical modifications of 193nm photoresists during a HBr treatment step. A 193nm model polymer was treated in a HBr plasma and analyzed with several characterization techniques.

The mechanical properties of the resist film were investigated by Dynamic Mechanical Analysis (DMA). This technique provides the glass transition temperature (Tg) of the resist film directly on the silicon substrate. The results were correlated with TGA and DSC analysis, from which characteristic temperatures of the resist are obtained. We observed a strong decrease of the Tg value after the treatment, indicating a plasticization of the resist film. This behaviour is interesting considering the common hypothesis of "hardening" of the resist layer after a HBr treatment.
In parallel, we used Fourier Transformed Infrared Spectroscopy (FTIR) and X-ray Photoelectron Spectroscopy (XPS) to characterize the chemical modifications of the resist polymer during the HBr treatment. FTIR analysis provides information on the resist chemistry over the entire volume. This is completed with XPS analysis which provides the chemical composition of the resist surface. We observed the formation of a carbon-rich superficial layer.

Moreover, the impact of the HBr treatment on the resist surface roughness was also investigated by 2-dimension Atomic Force Microscopy (AFM).
Finally, the influence of this process on the resist etch behaviour was evaluated. The resist was etched under various etch chemistries (O_2, Cl_2, CF_4, Ar,…) after a HBr treatment. The etch rate was measured by ellipsometry

1. A.P.Mahorowala et al., Proc. SPIE, 5753 (2005), 380.
2. H. Kawahira et al., Proc SPIE, 6153-45 (2006)