Temperature Programmed and Electron Stimulated Desorption From HafSOx Inorganic Resists

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Both near- and long- term challenges for nanomanufacturing require significant advances in lithographic approaches to obtain sub-ten nanometer half-pitch. One approach to meet these challenges is the development of inorganic resists that are based on clusters and nanoparticles. These resists are of considerable interest due to the potential for both high resolution and low line width roughness (LWR). Historically inorganic resists generally suffered from low sensitivity, however approaches have been identified to incorporate radiation sensitive ligands, which improve sensitivity while still maintaining high contrast.

This presentation will present background on the nanopatterning of $Hf(OH)_{4-2x-2y}(O_2)_x(SO_4)_y \cdot qH_2O$ (HafSOx) based inorganic resists. HR-TEM images were obtained from spin-coated films after various bake conditions to investigate the cross-sectional composition profile of HafSOx films. It was found that the films were not uniform, with a sulfur rich surface layer and an oxygen rich layer at the substrate/film interface. Fine-scale patterning of HafSOx using e-beam lithography has recently been demonstrated.[1] A cross-sectional TEM image of the patterned films is shown in Figure 1, with decreasing line spacing from 44 to 11 nm. The average FWHM line width was determined to be 9.0 +/- 0.7 nm.

We have begun studies to better understand radiation and thermal induced chemistries using electron stimulated and temperature programmed desorption from HafSOx. The goal is to better illustrate the role of the radiation sensitive peroxo species that are incorporated in the inorganic clusters that make up the inorganic resist. The primary observed electron stimulated desorption products are O_2 and H_2O. The time evolution of the O_2 and H_2O desorption yields suggest much faster kinetics for O_2 desorption, suggesting that the formation of the insoluble oxide network is driven initially by the desorption of peroxide groups. These data provide insight into the radiation-induced changes responsible for the solubility transition upon exposure and patternability during development.

[1] R.P. Oleksak, R.E. Ruther, F. Luo, K. Fairley, S.R. Decker, W.F. Stickle, D.W. Johnson, E.L. Garfunkel, G.S. Herman, D.A. Keszler, ACS Applied Materials and Interfaces **6**, 2917-2921 (2014).

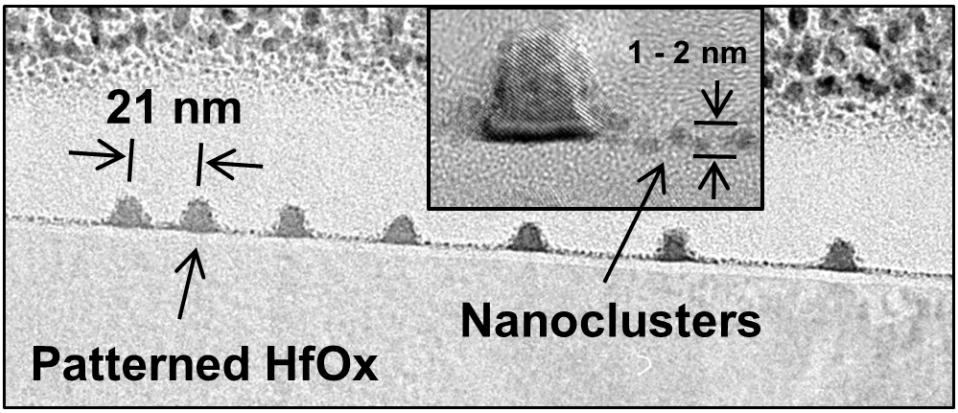

Figure 1: TEM cross sectional image of an electron-beam patterned HafSOx film after 800 µC/cm^2 exposure and development in 25% TMAH (a), HR-TEM image of single line (b).