Indium-based Sol-gel Precursor Films as Potential EUV Resist

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Extreme ultraviolet (EUV) lithography is one of the most advanced lithography techniques capable of achieving resolution below 10 nm at large scale. Organic-based photoresists such as chemically amplified resists (CARs) that produce excellent results in deep UV are not good candidates as EUV resist because of the low absorption cross-section of light elements. Inorganic resists, in particular organotin compounds such as SnOxo, have gained importance in EUV lithography. In our work, indium-based sol-gel precursors, predominantly indium nitrate hydrate films,[1] are studied as a potential EUV resist as indium has an EUV absorption cross-section comparable to tin. Due to the scarcity of EUV sources for research projects, we test our resist using electron beam (e-beam) exposure. We use two types of electron beam (e-beam) sources, flood gun and e-beam lithography (EBL). Using a calibrated e-beam flood gun, we find the indium-based sol-gel precursor films become insoluble, i.e., exhibiting a negative tone characteristic, when exposed to e-beam with energy from 500 eV down to 92 eV, the same energy as the EUV photons. Furthermore, to elucidate the mechanism behind the solubility switch, we study the chemical changes upon e-beam exposure using *operando* Fourier transform infrared spectroscopy and residual gas analysis. The sensitivity and contrast of indium nitrate hydrate evaluated from dose curves obtained using EBL are ~ 200 $\mu C/cm^2$ and 2.2, respectively, comparable to the values of a SnOxo benchmark sample.[2,3] The preliminary dose curve by exposing to an EUV flood gun indicates a sensitivity of ~ 20 mJ/cm^2. Line/space patterns using EBL are demonstrated for a half-pitch of 50 nm. These results demonstrate the potential of indium-based sol-gel materials as sensitive EUV resists.

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2. M. Valdez, A. Joshi-Imre, J. C. Bonner, L. Z. Preimesberger, J. L. Grayson, and **J**. W. P. Hsu, “Indium Nitrate Hydrate Resist Characteristics Evaluated by Low-energy Electron Beam Exposure,” Proc. SPIE, Advances in Patterning Materials and Processes XLI **12957**, 129570Q (2024)
3. M. Valdez, A. Joshi Imre, B. J. Dunn, M. Herrera Lara, and J W. P. Hsu, “Sensitivity and Contrast of Indium Nitrate Hydrate Resist Evaluated by Low-energy Electron Beam and Extreme Ultraviolet Exposure,” J. Micro/Nanopattern. Mater. Metrol. (JM3), (2025)