Fluorescence Imaging of Photoacids in Chemically Amplified Photoresist

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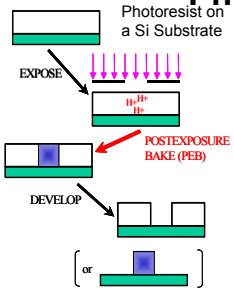
Chemically Amplified Photoresist

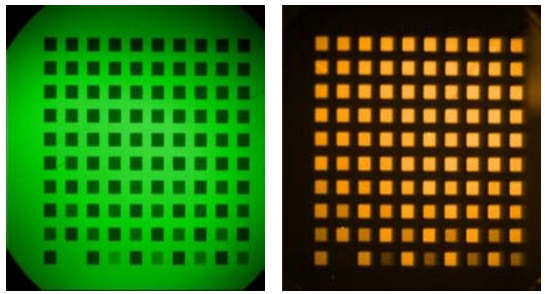


In modern photolithography, exposure of ultra-violet radiation causes the local generation of a photoacid. After exposure the photoresist is baked, a process in which the photoacid catalyzes a reaction in the polymer backbone that changes locally its sensitivity to chemical etch.

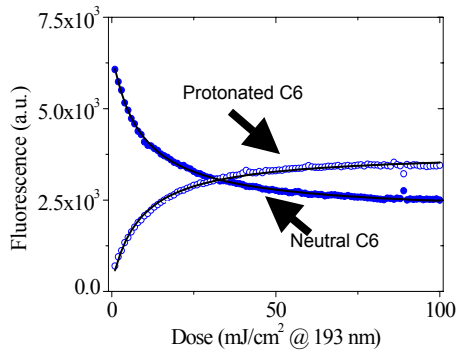
A long standing fundamental challenge in this field has been the direct measurement of the amount and location of these photogenerated acids

Photoacid vs. Exposure Dose

Neutral C6 Protonated C6

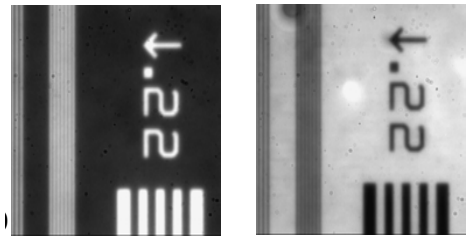


Exposing a thin photoresist film with a dose matrix and then imaging the resulting C6 fluorescence, we are able to directly measure the acid concentration vs. exposure dose. The left image is of neutral C6 fluorescence while the right image is of protonated C6 fluorescence. The resulting titration curve is shown below as fit by a simple theory. Knowing the pKa of the fluor allows us to accurately determine the local pH of the photoresist.



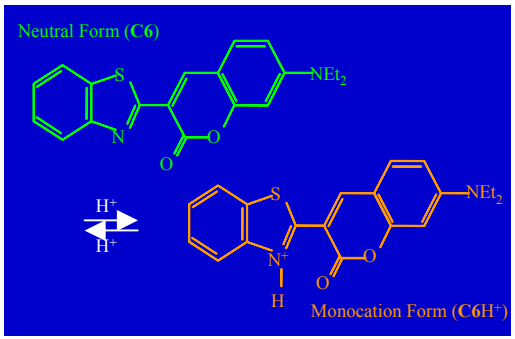
Lithographic Process Control

Neutral C6 Protonated C6



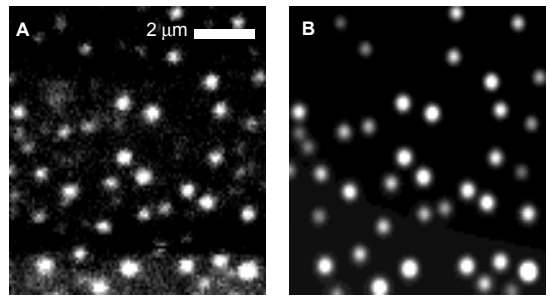
Doped into photoresist at 1 part per thousand, C6 has no affect on the lithographic process. Additionally, C6 fluoresces greenish -yellow, allowing images to be taken without causing further lithography. These fluors are being developed as a metrology tool for *in situ* monitoring of the lithographic process.

Coumarin 6 as a pH Sensitive Fluorescence Indicator



Our solution is to dilutely dope Coumarin 6 (C6) directly into the photoresist. C6 is a pH sensitive fluorescent molecule. The neutral species fluoresces green while the protonated species fluoresces yellow-red. Both of these fluorescence processes occur at much lower energies than the ultra-violet radiation needed for lithographic exposure.

Single Molecule Imaging



When C6 is doped into photoresist below 1 part per billion, the fluorescence images exhibit isolated diffraction limited spots corresponding to individual C6 molecules. The image on the left is raw data. The image on the right is a fit to the data on the left. The center position of each molecule (i.e. the center of each spot) can be determined with resolution of order 10 nm. We are developing this technique as a tool for nanoscale measurements of molecular diffusion in these photoresist polymers.

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