Materials characterization for Multi-Layer Electron Beam Lithography

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Successful implementation of Multi-layer lithography for fabricating three-dimensional structures involves depositing multiple layers of radiation sensitive materials with necessary dose and tone contrast[1]. Radiation sensitive materials (usually polymers dissolved in solvents) used in lithography are deposited on wafers using the spin coating process. Solvent incompatibilities can cause unwanted dissolution and intermixing of adjacent layers. Here we present the use of Hansen Solubility Parameters to identify compatible solvents and developers. The three dimensional representation of polymers and their solubility in different solvents makes it possible to select compatible solvents and developers.

Due to unavailability of resist polymer's chemical structure and other information on additives, characterization for solvent compatibility was done using Hansen Solubility Theory (HST)[2]. Solubility of a solute (in this case resist polymers) in solvents can be attributed to thermodynamics and molecular bonding. HST considers Dispersion, Polar and Hydrogen bonding forces, collectively termed as Hansen Solubility Parameters(HSP), between solute and solvent as independent parameters to make up a three dimensional space. Solvents and polymers can be visualized as points and spheres in Hansen space respectively. Polymers tend to dissolve spontaneously in solvents inside their spheres and are insoluble in solvents outside the spheres.
In this work, resists coated on silicon wafers (about 150nm thick) were exposed to 50 different solvents and that information was used to generate three dimensional hansen plots. Figure 1 and Figure 2 show two plots with spheres for positive and negative electron beam resists.These plots were used to identify mutually exclusive solvents for resist and suitable developers. The actual solubility values for the polymers may be different, but for this work absolute insolubility for a duration of 1-2min in the process of spin coating was required.

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[1] R.K. Bonam, et.al., "Towards outperforming conventional sensor arrays with fabricated individual photonic vapour sensors inspired by Morpho butterflies". *Nature communications*, *6*, 2015

[2] C. M. Hansen., Hansen Solubility Parameters - A user's handbook. Second Edition, CRC Press, 2007

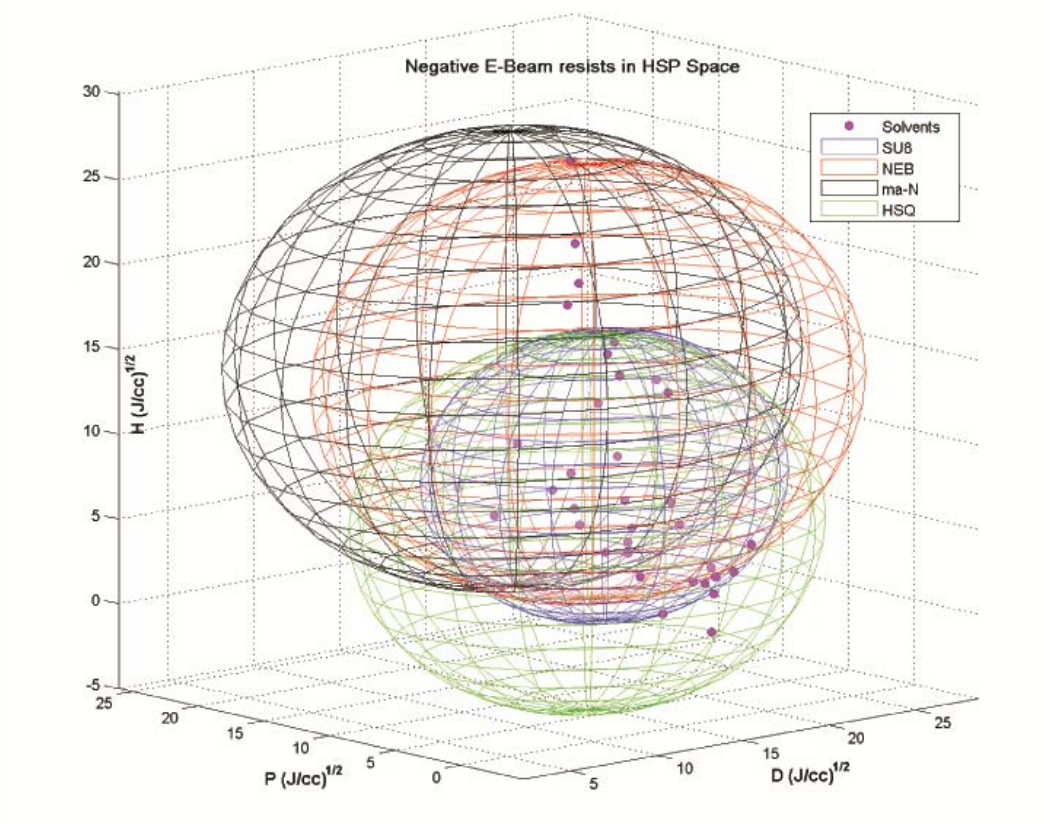

Figure 1

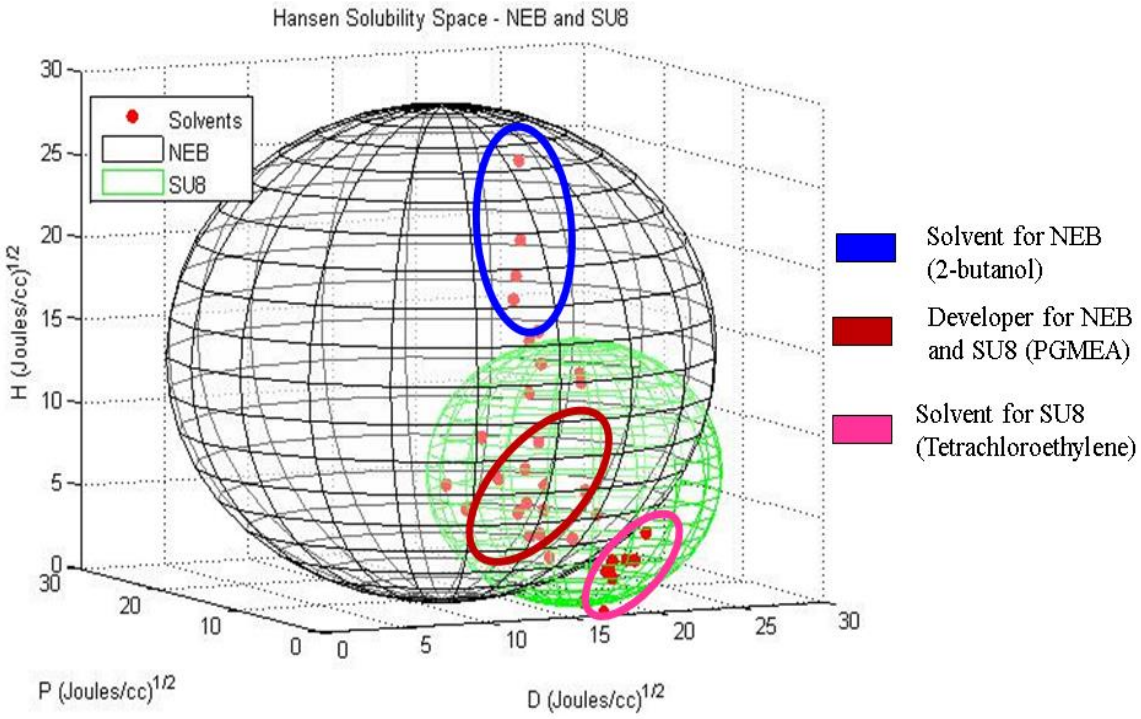

Figure 2