Low Dose Patterning of HSQ For Use As A Silicon Etch Mask

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Patterning of hydrogen silsesquioxane (HSQ), using electron beam lithography, typically requires a high clearing dose and therefore a long exposure time. However, it is possible to use a much lower dose to achieve the same, and in some cases an improved, result. The negative tone e-beam resist XR-1541, which contains HSQ, can be used as an etch mask after exposing it to a dose much lower than the clearing dose. While the HSQ thickness much be much thinner, it is still sufficient to effectively mask an underlying substrate for etching or further processing.

In this work, XR-1541 was deposited on SOI samples and an array of one micron boxes was exposed using a 30keV electron beam at varying doses. After developing the samples, the thickness of the remaining resist was measured and the clearing dose was found to be approximately $1000\mu C/cm^2$. The samples were then etched using ICP-RIE, where the patterned XR-1541 acted as an etch mask for the underlying Si surface. Results show that the silicon etch rate is much higher than the XR-1541etch rate (selectivity can be greater than 200), so even patterns that have a minimal resist thickness prior to plasma etching can be effective in protecting the substrate. Patterns that were exposed with a dose above $480\mu C/cm^2$, which is less than half the clearing dose, successfully acted as a robust etch mask for the underlying silicon substrate.

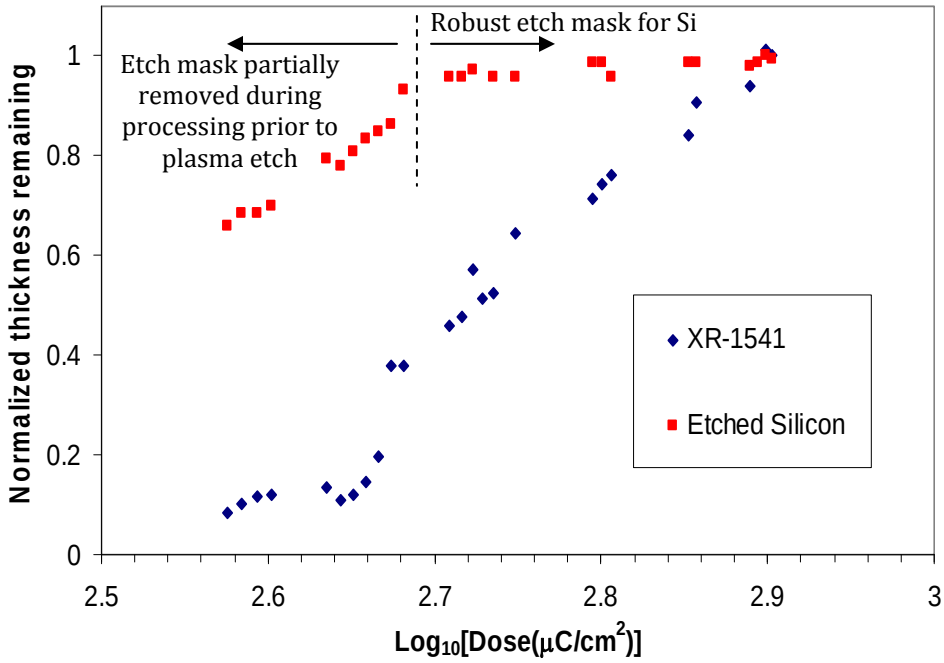

Figure 1: Post-RIE (ICP power = 100W) etch measurements of silicon protected by patterned XR-1541 e-beam resist. The resist successfully acts as a robust silicon etch mask for any dose greater than 480μC/cm². This is less than 50% of the clearing dose required for this process.

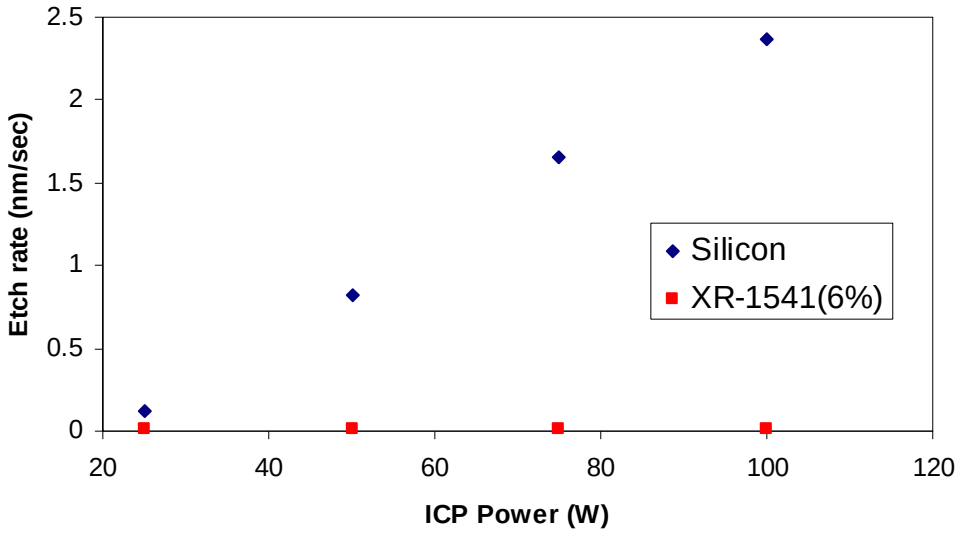

Figure 2: Etch rate of XR-1541 is much less than silicon during plasma etch (RIE power = 10W, Pressure = 50mTorr, O_2 = 5sccm, SF_6 = 50sccm).