High Aspect Ratio Features in PMGI using Electron Beam Lithography and Solvent Developers

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We present a high contrast electron-beam lithography process using Polydimethylglutarimide (PMGI) as a resist. The key feature of this process is development by a weak solvent, Xylenes, which is commonly used to develop ZEP. We obtained a contrast of about 36, five times higher than the reported contrast in PMGI and PMMA, about 6.7.[1]Using this high contrast PMGI process, features with aspect ratios more than 20 can be easily achieved. Figure 1 shows the contrast curve of a 340 nm PMGI film when developed with Xylenes at room temperature. The sensitivity of the resist, the dose at which 20% of the resist thickness is removed, is about 2640 μC/cm^2 at an electron beam energy of 75 keV. The trade-off made in this process for the high contrast is the higher required dose compared to PMMA, almost four times, which makes this a slow resist. On the other hand, the etch resistance of PMGI is higher than PMMA, and has better thermal stability.[2]

One possible application for this high contrast PMGI process is in the fabrication of T gates for high-speed transistors. Here a high aspect ratio trunk is desirable to give a short gate length while putting the gate head high above the surface to reduce parasitics. A single step electron beam exposure and developing can make the required profile in a trilayer resist stack. PMGI is used as the bottom layer where the stem is formed, P(MMA-MAA) is used to facilitate the lift off process, and the dimension of the gate head is determined by the opening in the ZEP top layer. The P(MMA-MAA) layer is exposed with DUV (220 nm) before spinning the top ZEP. Electron beam lithography is done with an area dose of 8000 μC/cm^2, and the resist stack is developed for 100 seconds in Xylenes. An SEM image, Fig. 2, taken after cleaving shows the cross section of the resist stack. We believe that the closure at the bottom of the profile is an artifact of the sample cleaving. In the second experiment PMGI layer was placed between ZEP on top and PMMA on the bottom. This stack is exposed with the same dose as the previous experiment, and developed for 70 seconds in Xylenes. Figure 3 illustrates the 24:1 aspect ratio achieved in PMGI.

[1] B. Cui, T. Veres, Microelectronic Engineering **85**, 810–813 (2008)

[2] A. Lebib et al., Microelectronic Engineering **53**, 175 – 178 (2000)

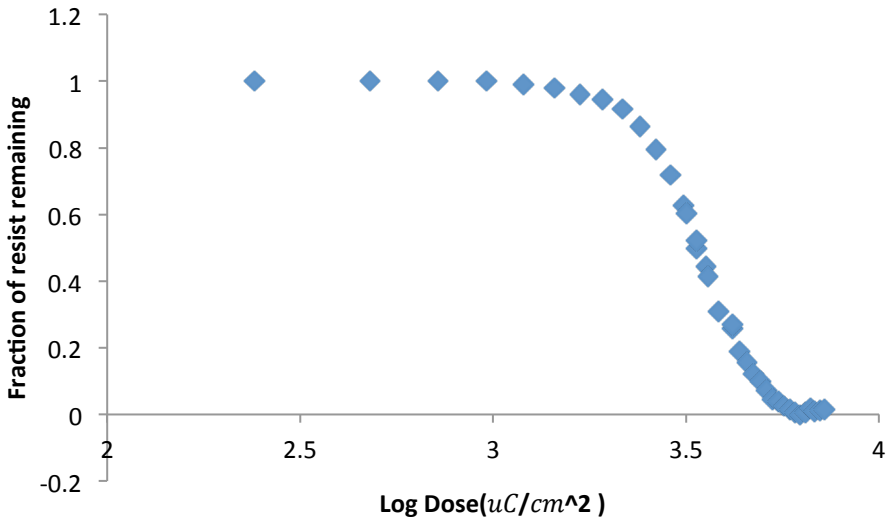

Figure 1. Contrast curve of PMGI.

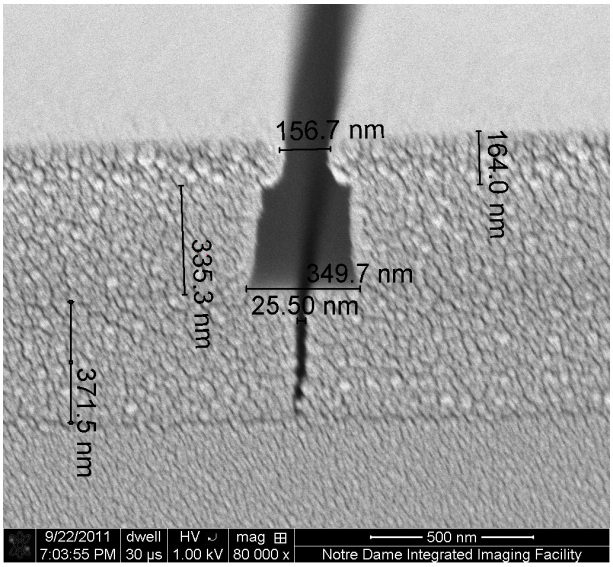

Figure 2. Resist profile for T-gate process.

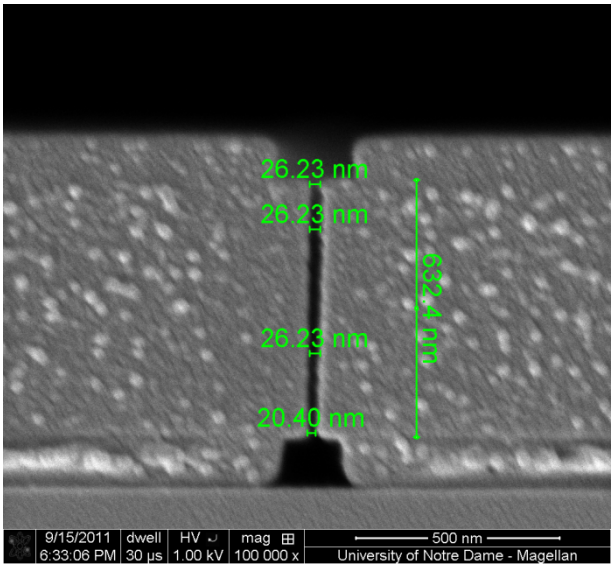

Figure 3. High aspect ratio profile in PMGI