Comparison of HSQ development methods for sub-10 nm electron beam lithography using accurate linewidth inspection

D. S. Macintyre and S. Thoms

James Watt Nanofabrication Centre, School of Engineering, University of Glasgow, Glasgow G12 8QQ, UK

There has been much recent interest in determining the resolution limits of hydrogen silsesquioxane (HSQ) as a negative tone electron beam resist. Various techniques for improving the resolution and contrast have been reported in the literature. These include the use of concentrated tetramethyl ammonium hydroxide, hot development, potassium hydroxide, salty development and the use of dilute hydrofluoric acid dips. One difficulty in comparing the results from different research groups is that measurements are made using different electron microscopes working at various beam energies. These variations mean that useful comparisons at the nanometre scale are not possible. In this paper we present results comparing these different development techniques using a unified inspection regime.

Reliable and accurate measurement of linewidths is vital for this comparison, and the method chosen here is that of coating the fabricated structures with a conformal 2 nm tungsten film and then using backscattered electrons to measure the linewidths using an FEI Nova NanoSEM 630. The correct choice of imaging energy is important using this approach as is illustrated in Fig. 1 and Fig. 2. If the beam energy is too low then electron scattering blurs the measured linewidth, but excessive beam energy reduces the contrast because of the increasing electron range. A beam energy of about 20 kV was found optimum for the 35 nm thick HSQ used in the images shown. We have shown that this method gives linewidth accuracies of about 1 nm [1].

Factors in addition to linewidth are important and include resist sensitivity, process latitude, minimum pitch and resist aspect ratio. All of these issues will be discussed in the paper.

1. S. Thoms and D.S. Macintyre, J. Vac. Sci. Technol B 28, C6H6 (2010)

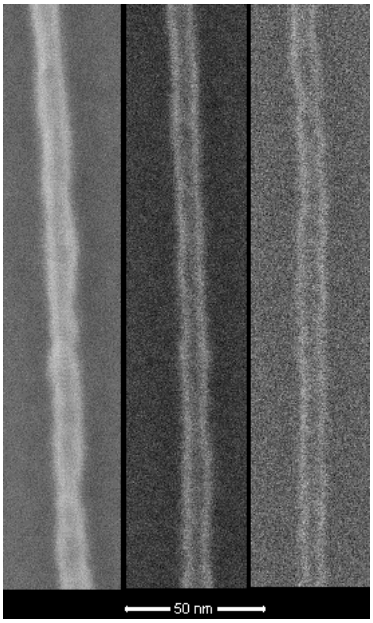

Figure 1. A 5 nm HSQ line on silicon coated with 2 nm tungsten and imaged using backscattered electrons at (from left to right) 10, 20 and 30 kV.

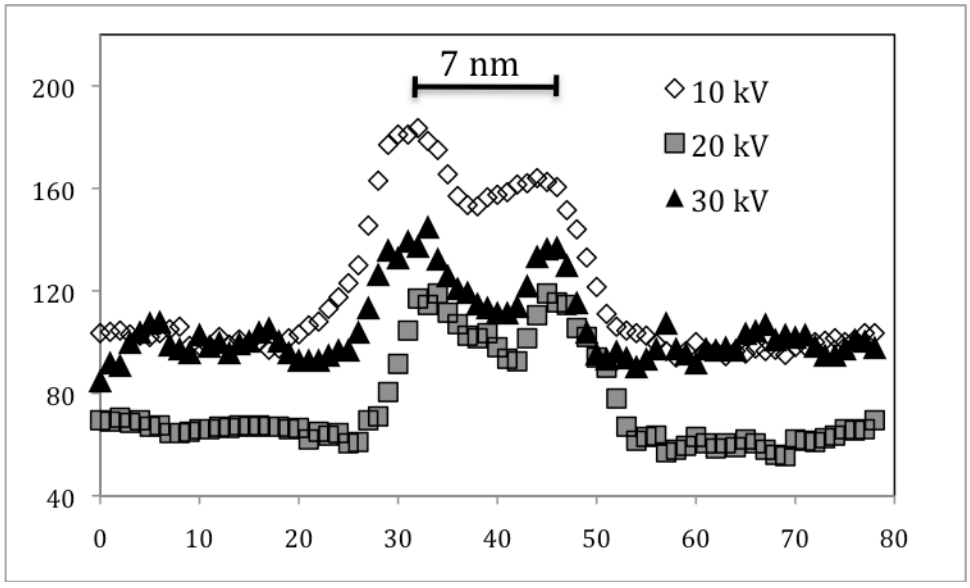

Figure 2. Intensity profiles from the above images after smoothing. The resolution improves with beam energy, but the contrast degrades above 20 kV.