# Sub-10 nm Helium Ion Beam Lithography with Metal–Organic Resists


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A class of metal–organic resist materials, originally developed for electron beam and extreme ultraviolet (EUV) lithography, has exhibited its best performance with helium ion beam lithography, yielding single pass lines as narrow as 7 nm on 18 nm pitch when written on silicon substrates. The negative tone resists, structurally defined by a heterometallic ring, combine high molecular weight and low density to provide high resolution writing capability and extraordinarily high etch selectivity for silicon (130:1 has been demonstrated) when subjected to a pseudo-Bosch inductively coupled plasma–reactive-ion etch (ICP-RIE). This talk will describe the Monte Carlo simulations that guided the design of the resists, the mechanisms by which the resists work, various chemical modifications that have been used to optimize lithographic writing speed versus resolution, and the results obtained with 35 keV helium ions compared to 100 keV and 30 keV electrons. Notably, etched structures as narrow as 7 nm are demonstrated in silicon and a 9 nm half-pitch process is achievable both before and after etch. By combining ultra-high resolution with ultra-high etch selectivity – and the flexibility to be exposed by ions, electrons and EUV – this class of resists is a versatile lithographic material with the potential for further customization to address a wide range of nanofabrication challenges.


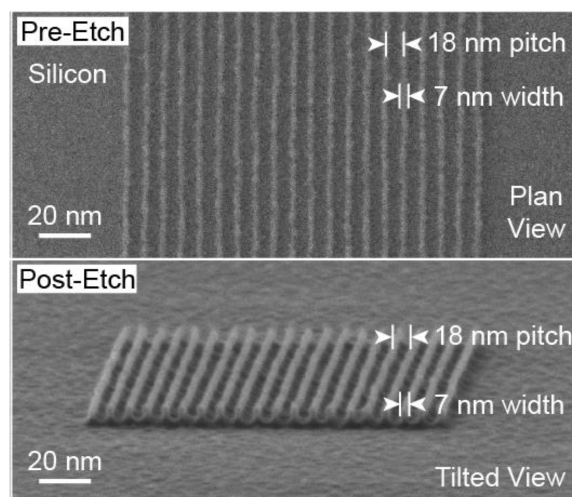


Figure Caption: Resist that was spun onto silicon and then exposed by helium ion lithography is shown before (top) and after (bottom) a pseudo-Bosch ICP-RIE. The resultant lines have an average width of 7 nm spaced on 18 nm pitch. Images were captured with helium ion microscopy.

***Preference: Oral Presentation***

**50 word "short summary":**

It is demonstrated that a class of metal–organic, negative tone resists can yield sub-10 nanometer features when exposed with helium ion beam lithography. Single pass lines as narrow as 7 nm on 18 nm pitch are realizable on silicon both before and after reactive-ion etch.