Understanding the sources of unwanted etch in ion beam sputter deposition production of EUV mask blanks

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EUV lithography (EUVL) is the leading solution for lithography at the 22nm node and beyond. Mask blank defects are one of the remaining challenges to overcome before production. Mask blanks are produced by ion beam sputter deposition. A detailed study of the defects on EUVL mask blanks shows many come from the shields used to keep deposition off the chamber walls and edges of the target. Inspection of the shields shows net etch in areas far from the ion beam, suggesting that this etching liberates particles that contaminate the mask blank. Understanding the sources of this etching is therefore critical to reducing defect levels and ultimately ensuring the success of EUVL.

In this work, we investigate the causes of and developed methods to reduce this unwanted etch. Initial investigations of ion beam core width allowed the process parameters to be optimized to narrow the beam. Figure 1 shows results of one such optimization in which the beam width (measured on the target) was significantly reduced. Figure 2 of pinhole camera measurements at the etch location shows large components of the etching species coming from both the beam region (presumably from scattering off the background gas) and directly from the ion source. These etching species were further investigated using a retarding field energy analyzer, which suggests energetic neutrals are the etching species. Our observations are compared with simulations of the effect of charge exchange collisions between the ion source grids. Finally we will suggest methods to mitigate the unwanted etch through process and tool changes.

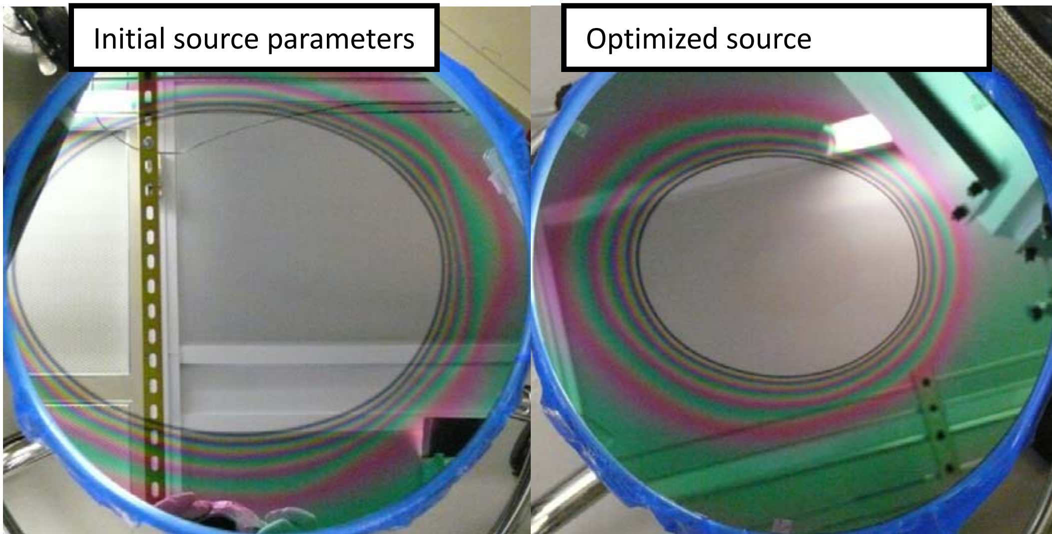

Figure 1: Target etch patterns with initial and optimized source parameters, showing reduction in beam width.

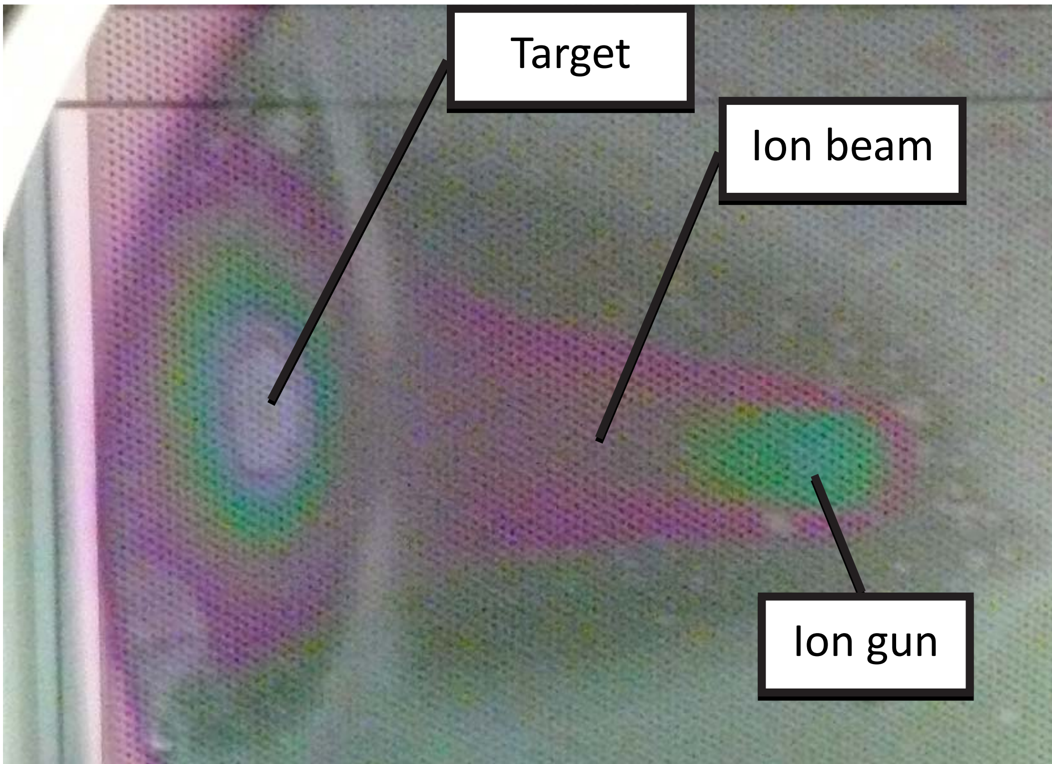

Figure 2: Pinhole camera image of ion source, ion beam, and target during deposition taken with the pinhole far outside the main ion beam in the location of the net etch.