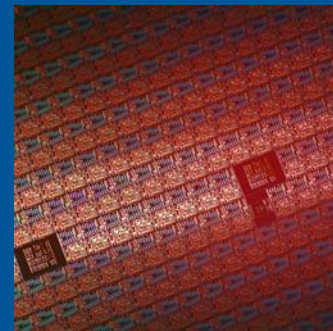




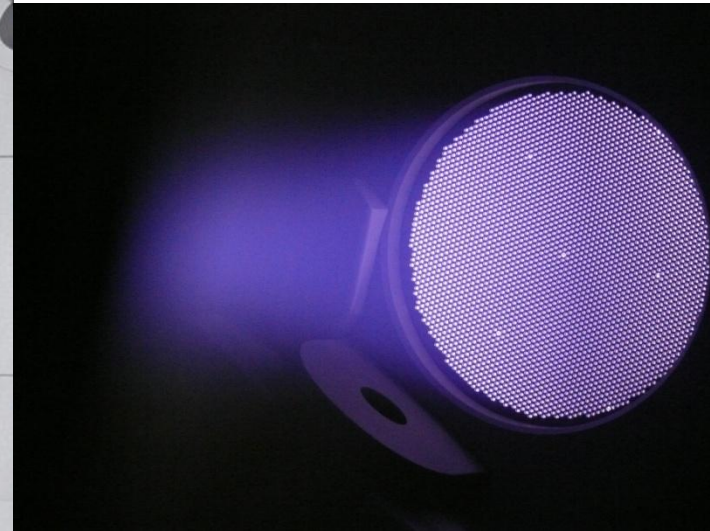
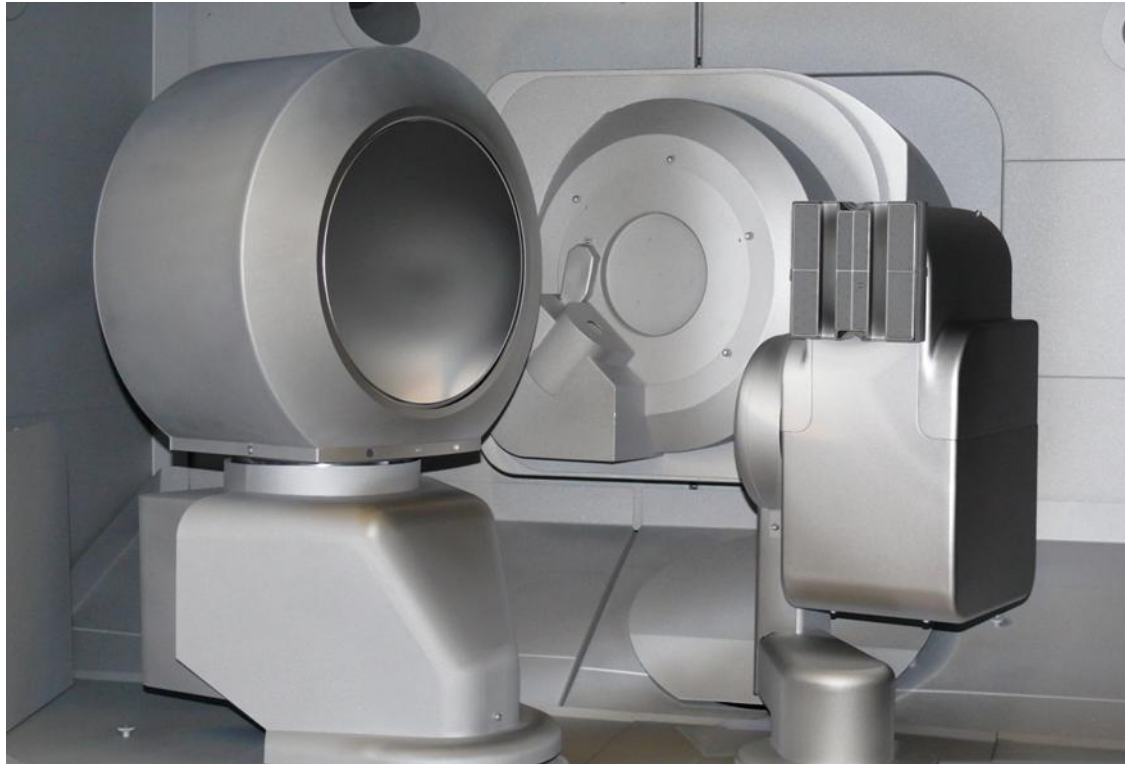
Accelerating the next technology revolution

MLD deposition tool characterization

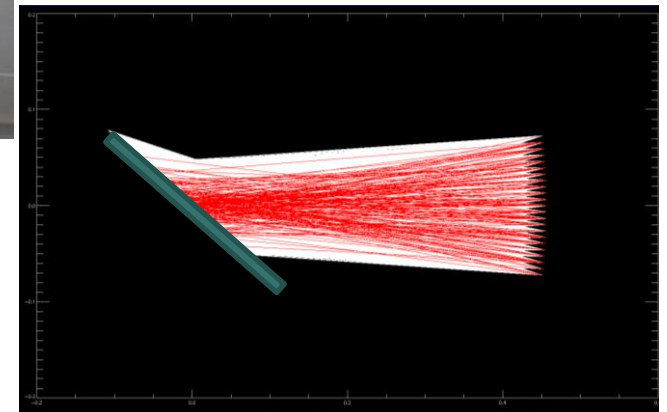
Patrick Kearney



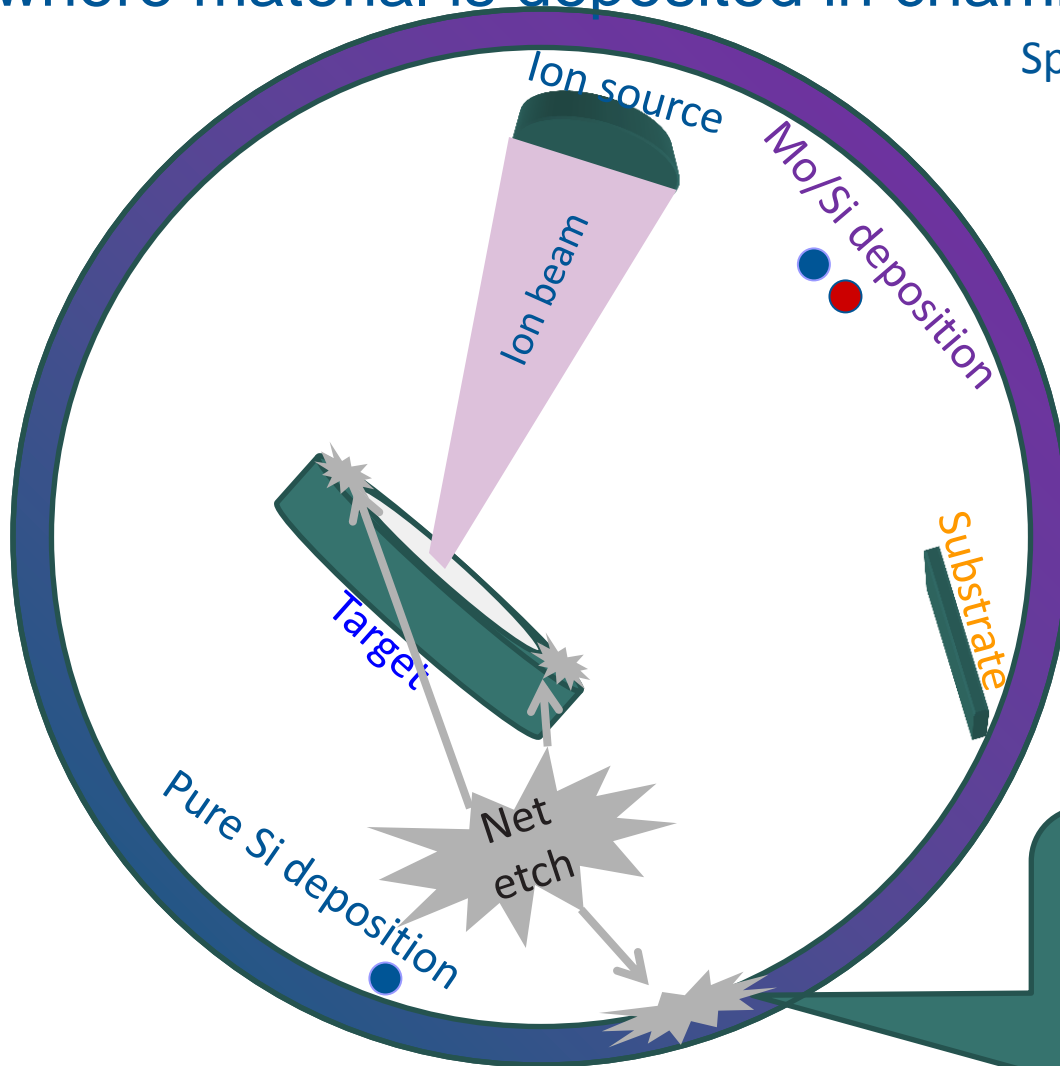
SEMATECH's mask blank deposition tools



Ion beam sputter deposition;
Theory predicts 99.9% of beam hits target.



Ion target interaction and gas scatter determine where material is deposited in chamber



Sputtered atom on Ar scattering

Mo

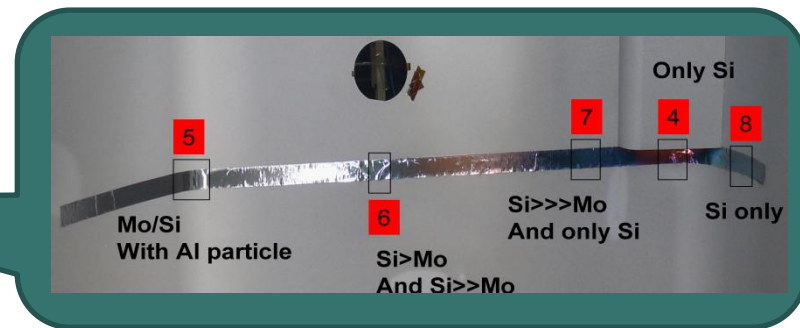


Mo is heavier than Ar so it keeps moving forward.

Si

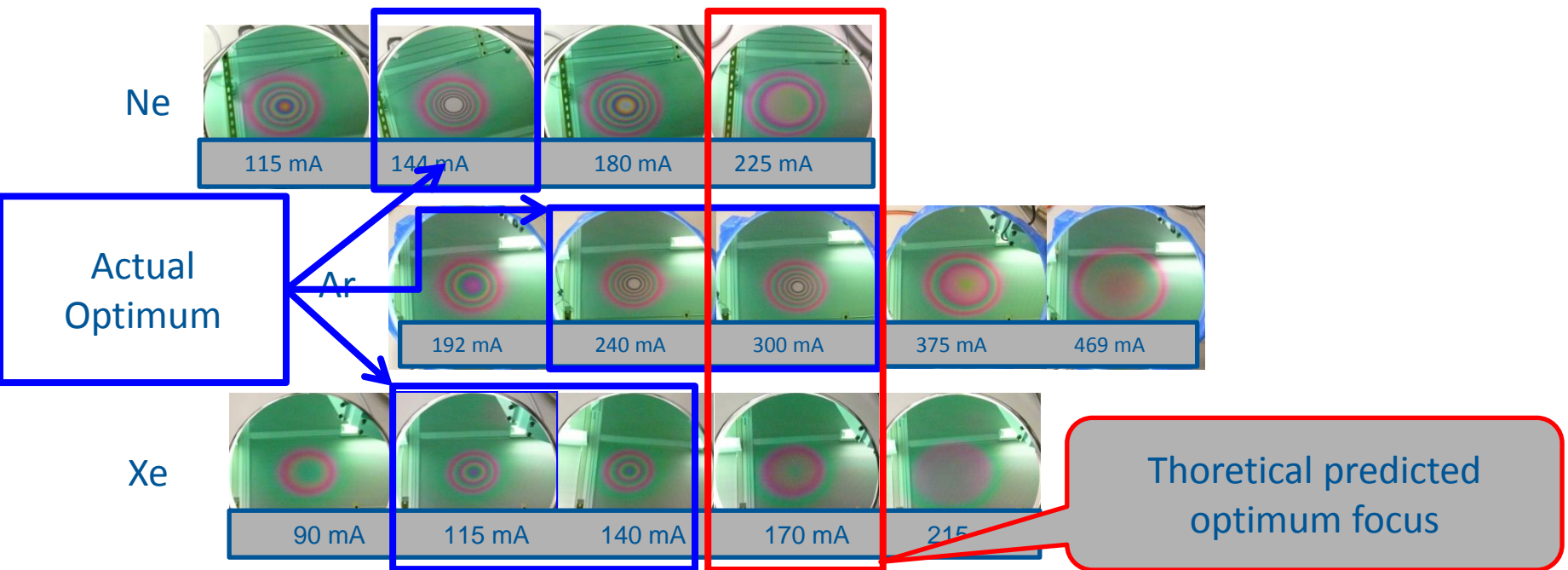


Si is lighter than Ar so it reflects off moving backwards sometimes.



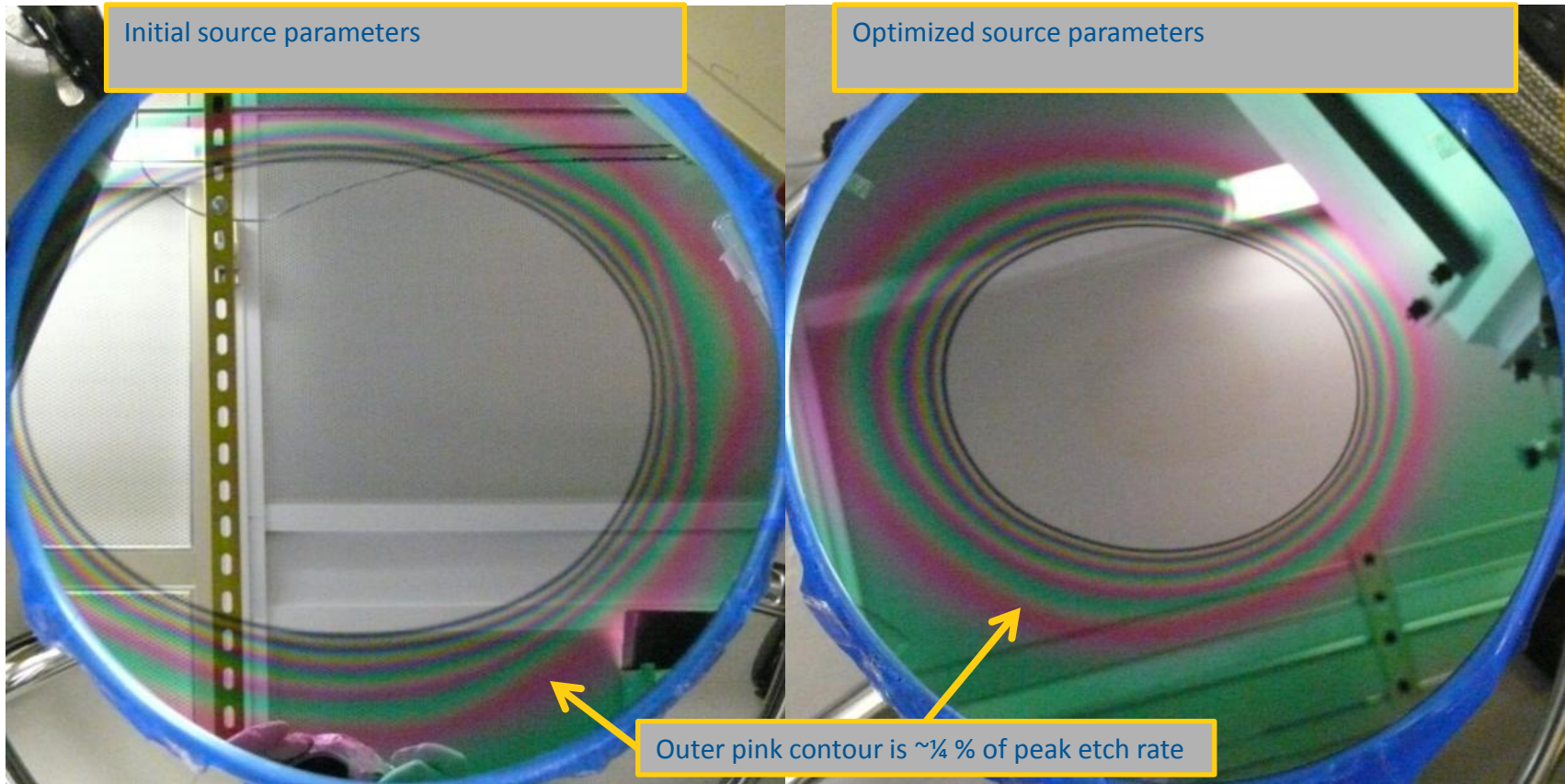
Testing Kaufman beam divergence theory and optimizing our source

- Gas flow, suppressor voltage, beam voltage and current were optimized for different gases



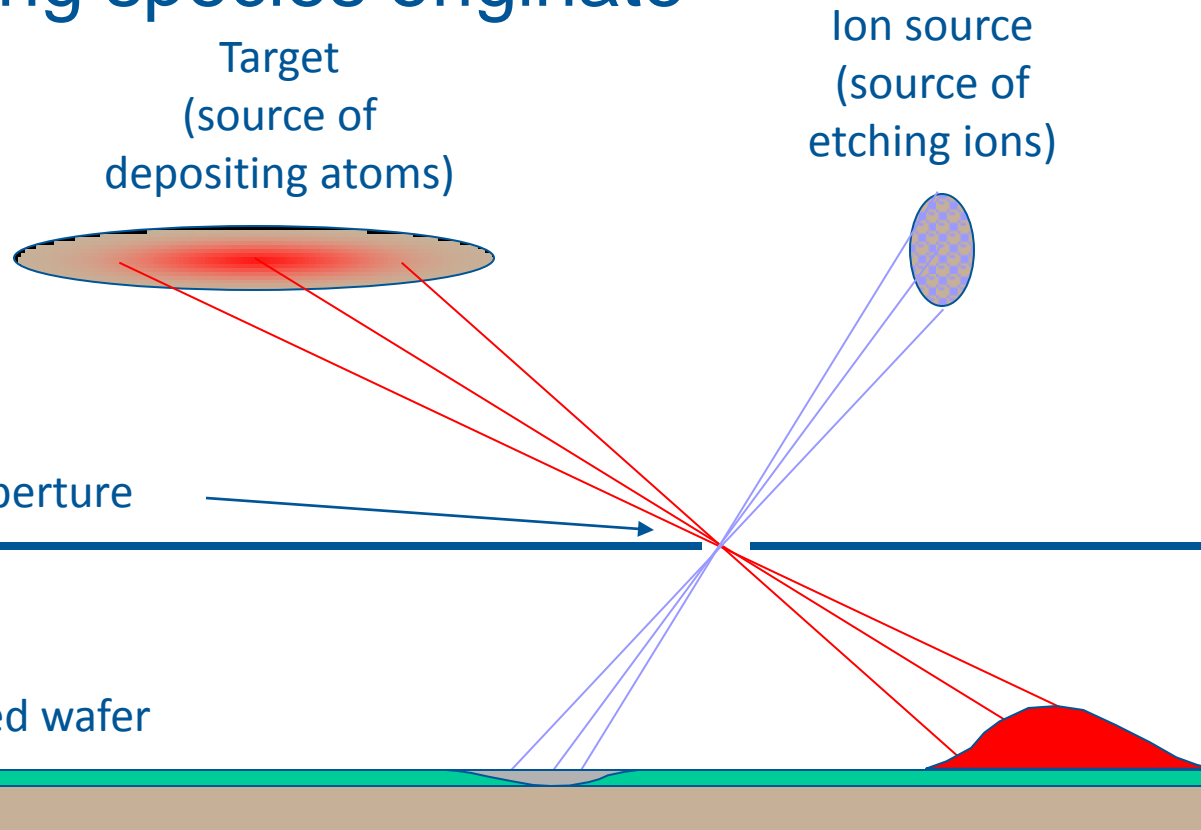
Kaufman et.al., J. Vac. Sci. Technol., Vol. 21, No. 3, Sept./Oct. 1982.

Optimized beam profile is much narrower than standard conditions



Higher operating voltages/currents can give narrower focus on target.
New parameters give $< \frac{1}{4}$ % of peak etch at edge of target.

Using pinhole cameras to image where etching species originate



Assumes ions and atoms move in straight lines. Alternately gives an image of the last collision the atom/ion had.

Can indicate where ions/atoms are coming from.

Pinhole camera shows where etching species originate

80% of etching comes from beam scattering
20% of etching comes directly from source

- Theory does not predict such high angle emission from ion source.

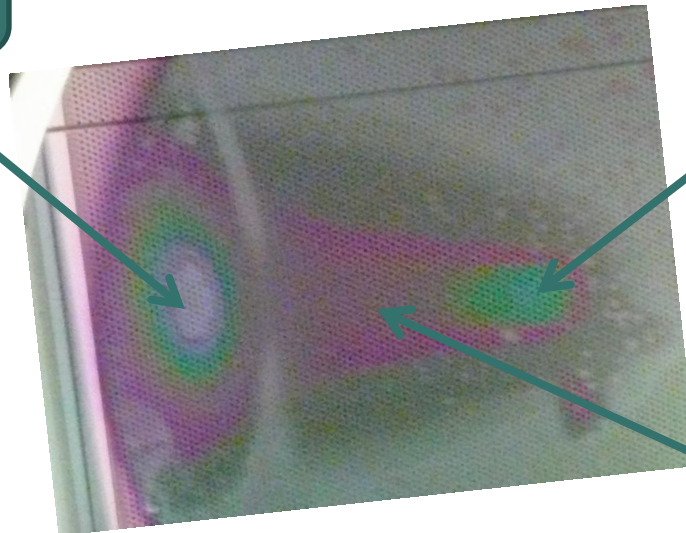


Pinhole camera installed in etch area



Target

Ion source



Ion beam

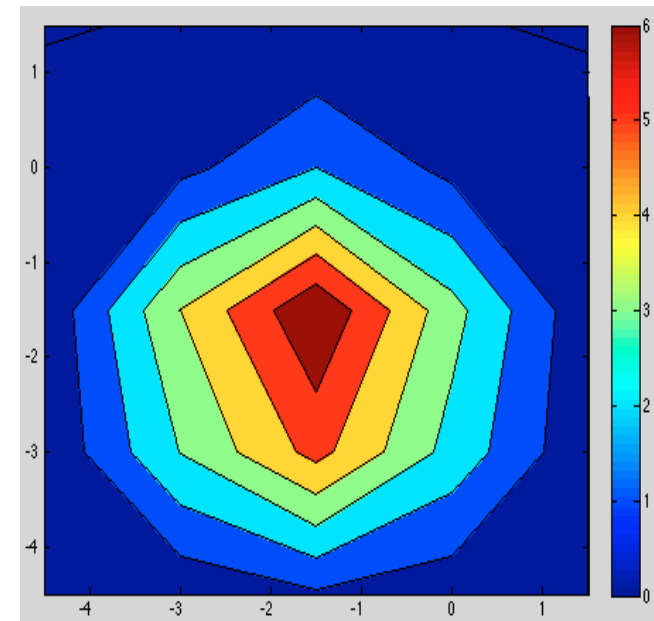
Measuring etching species with SEMION ion flux analysis system



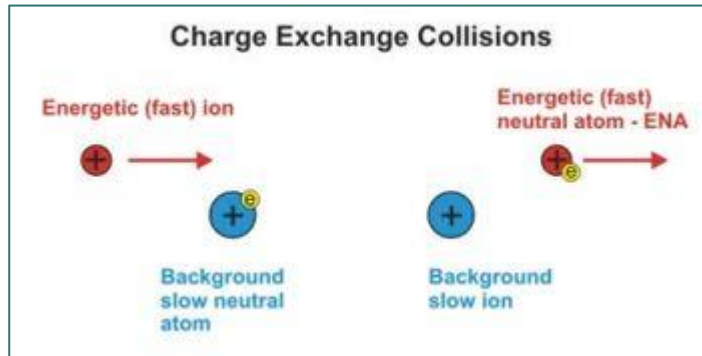
- SEMION is a retarding field ion analyzer.
- Was able to measure the ion beam.
- Detected nothing in the net etch area.
- Does this mean etching particles are neutral?



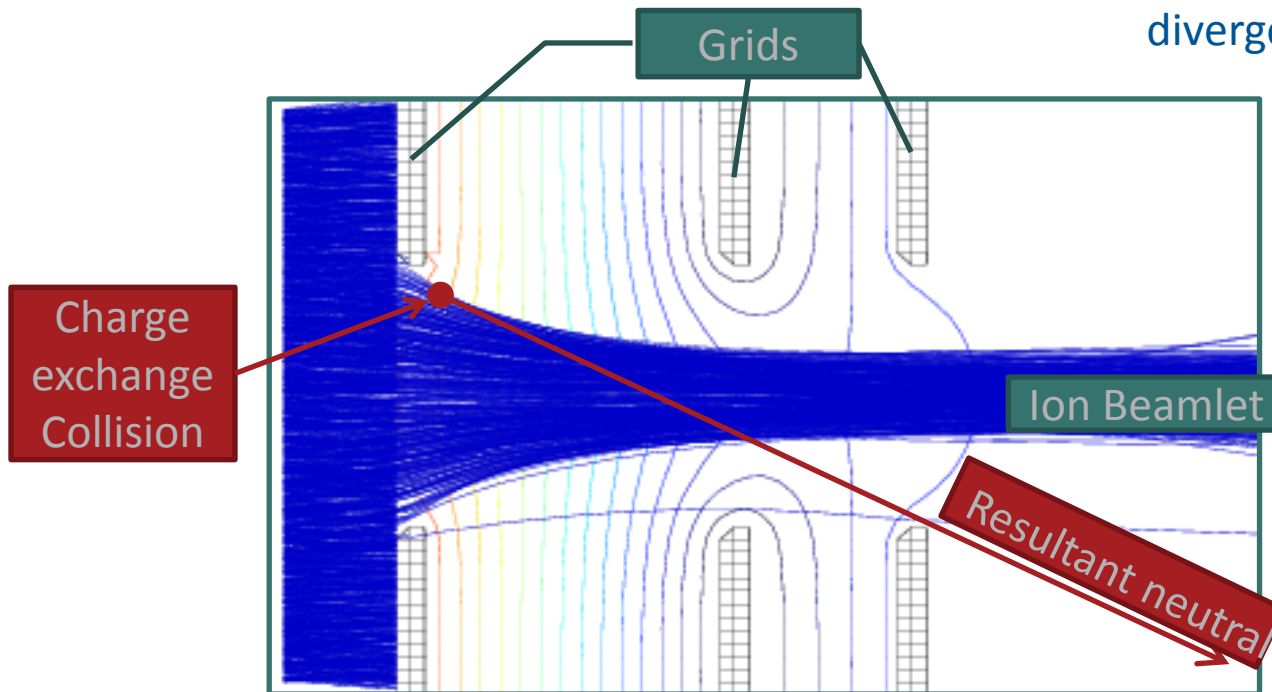
Ion beam profile



Are charge exchange collisions (CEX) causing the etch we see?



- CEX creates a neutral with the velocity of the starting ion.
- The neutral is not focused by remaining grids.
- Neutrals form broad divergent halo around beam.



Working to simulate CEX in our ion source



- Tech-X is developing ion source model to include CEX effects.
- Will use simulation to study how to reduce the effect.

Conclusions



- Used ion beam profile measurements to sharpen beam focus to keep core of beam on target much better than older process conditions.
- Ions are striking the target shields and wall shields in areas where the Kaufman model indicate they shouldn't.
- Etching species come from the direction of the ion beam and ion source and appear to be neutral.
- Results indicate neutrals may be causing etching, further investigating charge exchange collisions as potential source.