Particle Motion During Magnetron Sputter Deposition

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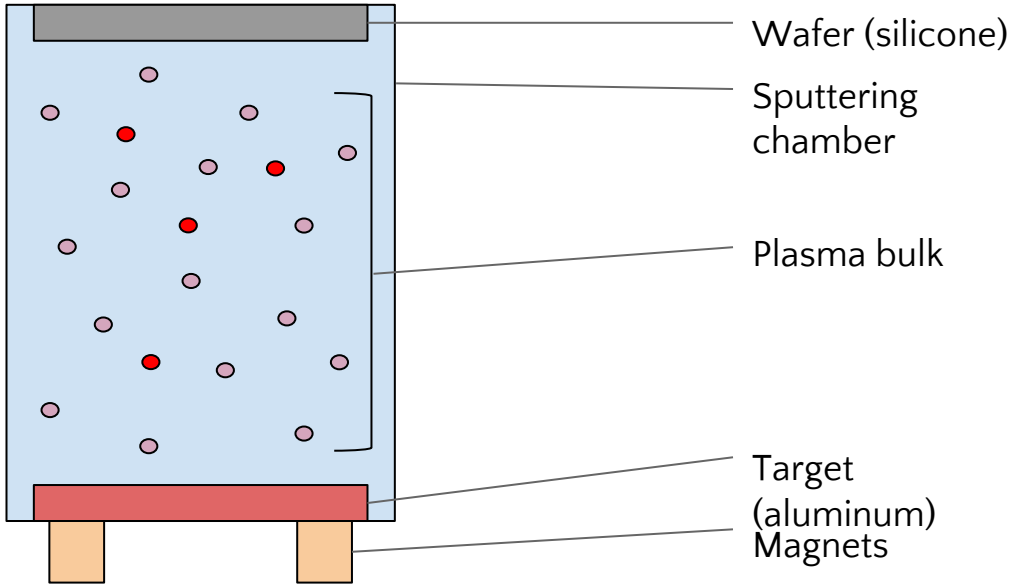
A Major Qualifying Project Submitted to the Faculty of WPI, completed in partial fulfillment of the requirements for the Degree of Bachelor of Science.

Magnetron Sputtering Deposition



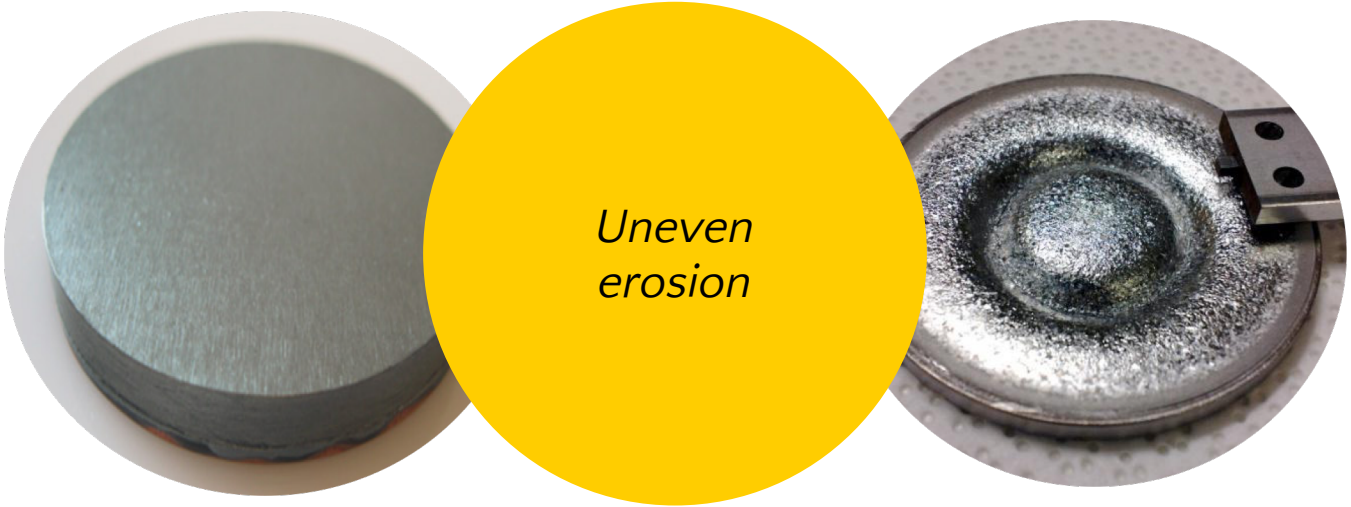
What is it?

- Plasma-assisted thin film deposition technique
- Target erosion through particle bombardment

Why is it used?

- Used for creating semiconductor materials (integrating computing chips, electron microscope slides)

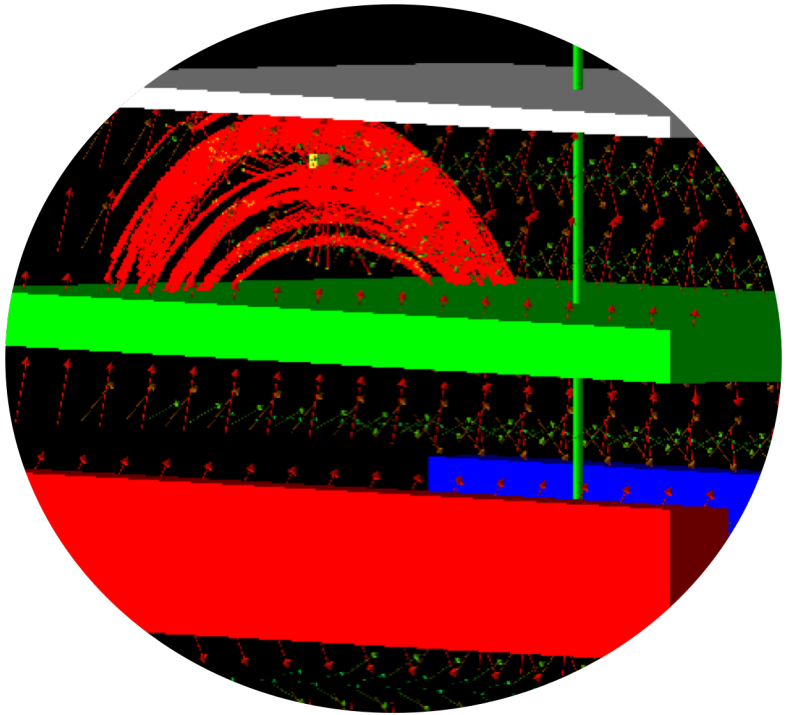
Target erosion



Pre-sputtering

Post-sputtering

Particle Motion Simulation

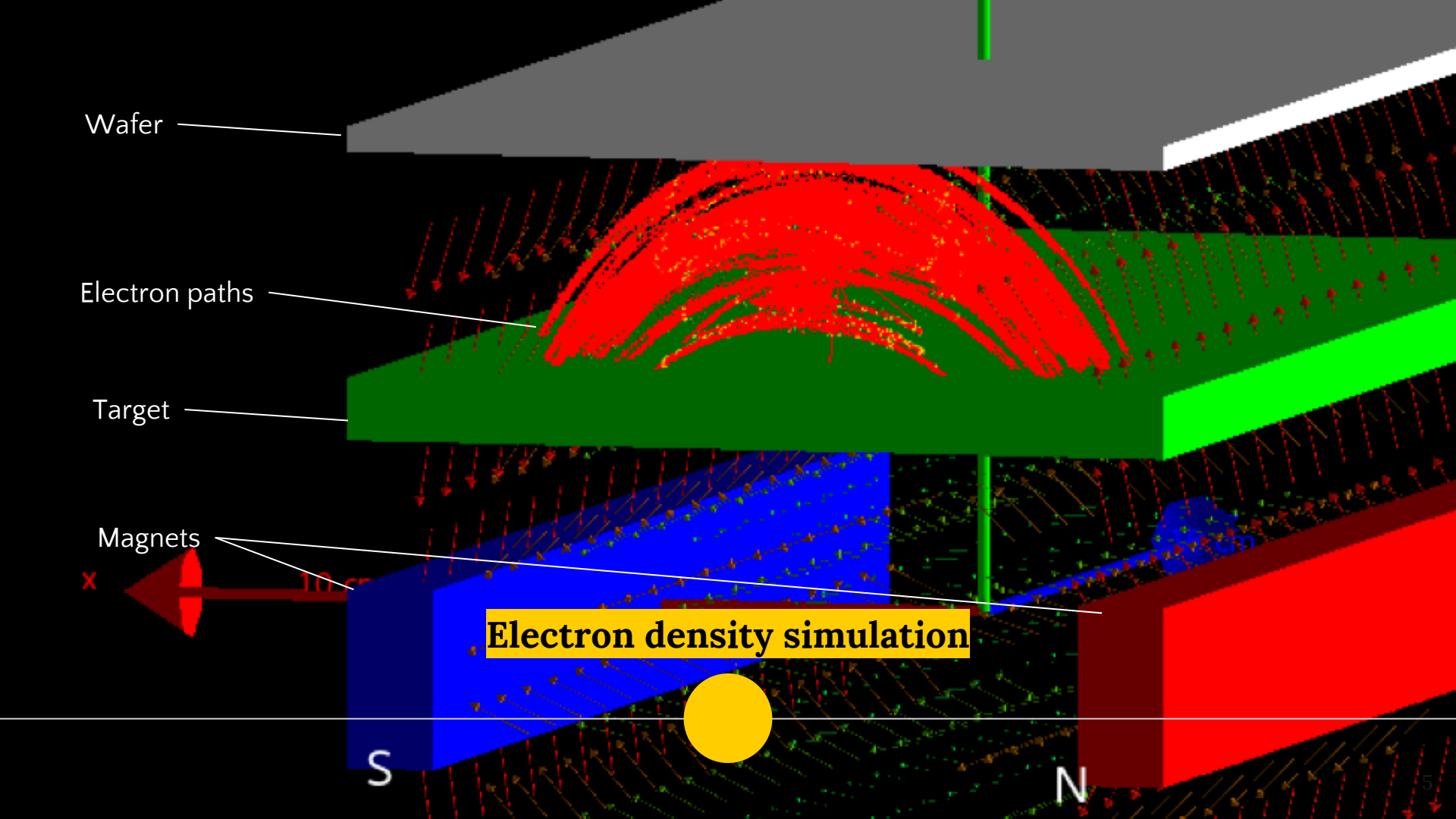


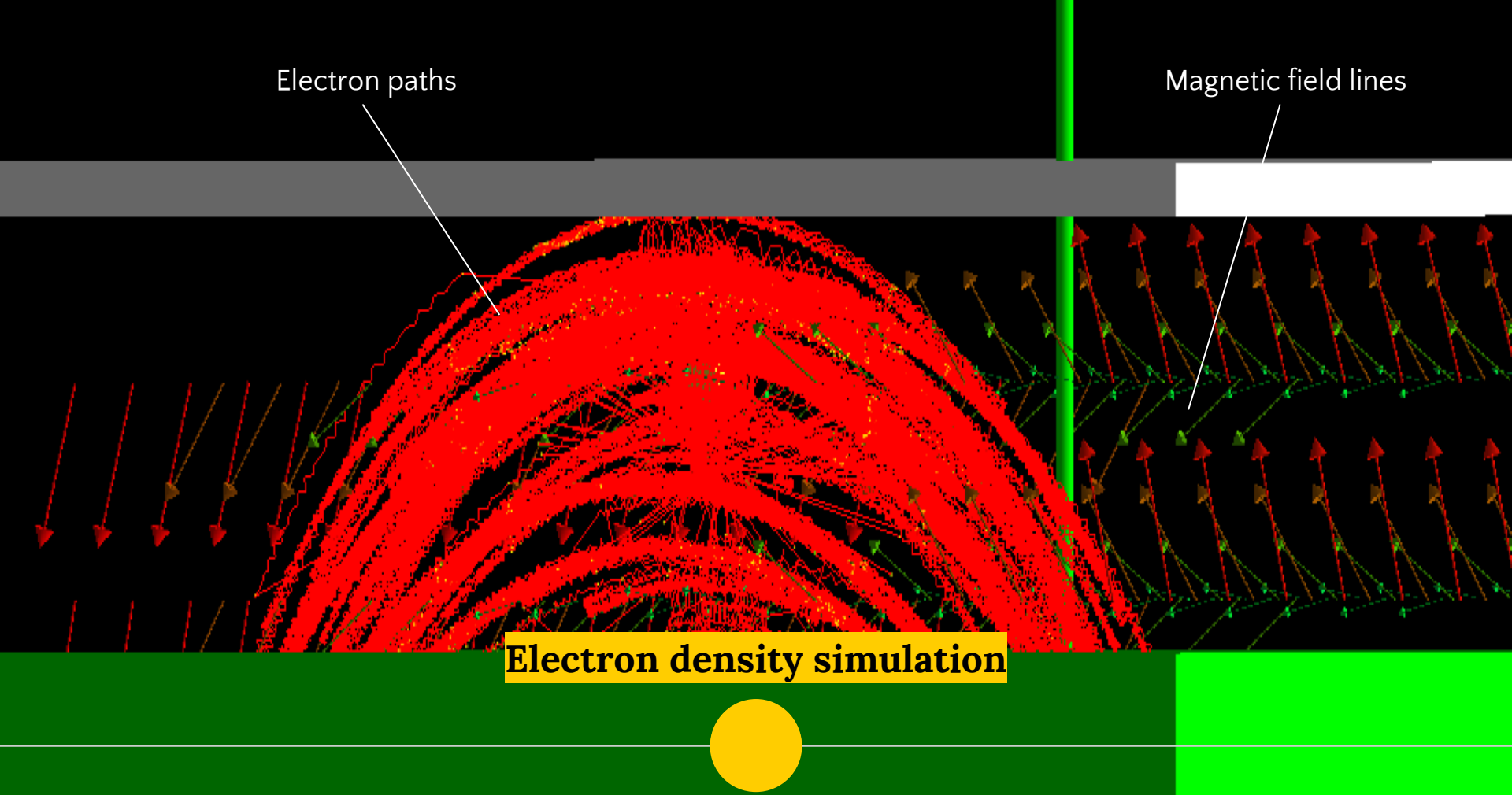
What could we control?

- Electron energy
- Magnetic field strength
- Electric field strength

What was native to Geant4?

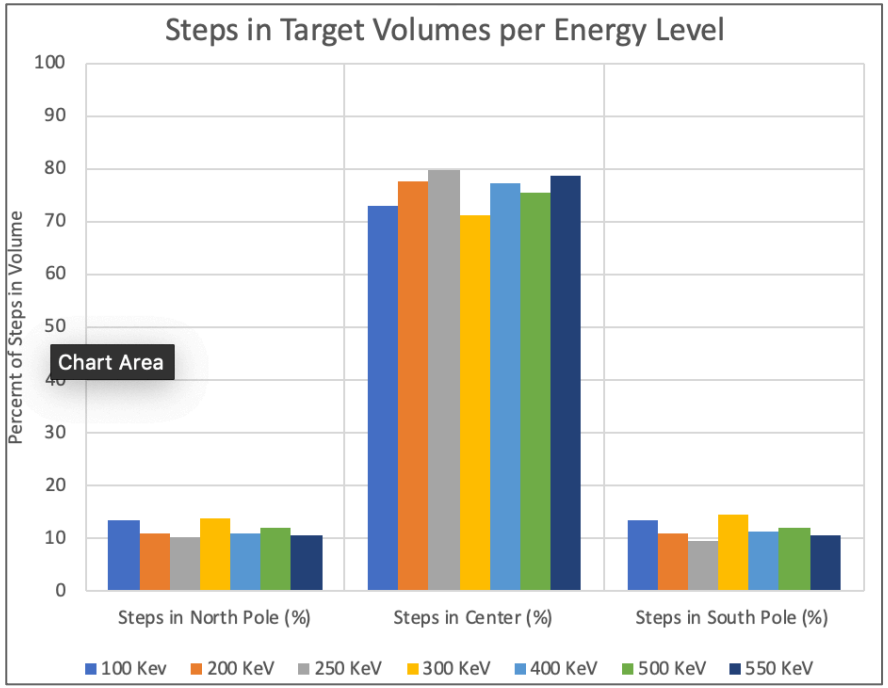
- Electron motion paths


Wafer
Electron paths
Target
Magnets
x
Electron density simulation
S
N



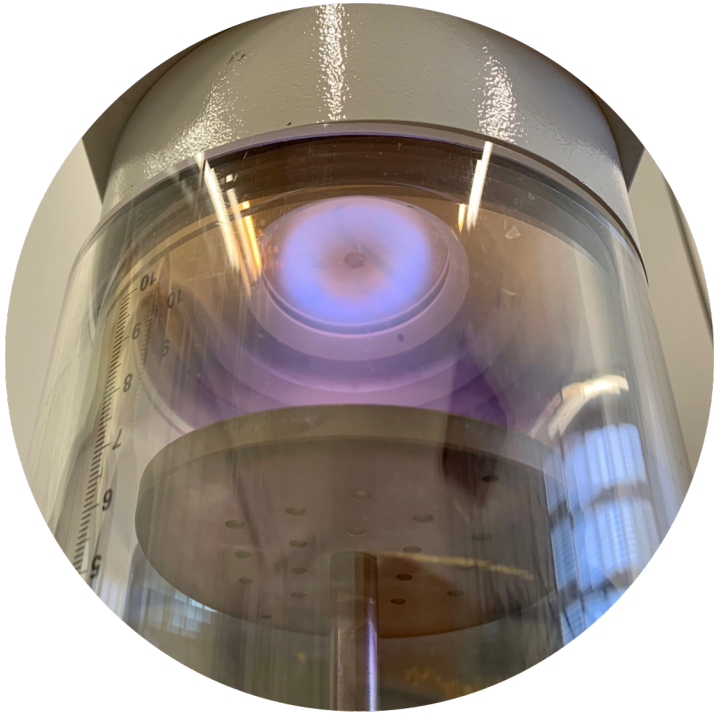
Electron density simulation

Simulation Results



Electron Energy (KeV)	Steps in North Pole (%)	Steps in Center (%)	Steps in South Pole (%)
100	13.49	72.96	13.55
200	11.21	77.66	11.13
250	10.35	79.91	9.74
300	13.87	71.38	14.75
400	11.08	77.48	11.44
500	12.14	75.70	12.16
550	10.57	78.90	10.53

Sputtering Experiments



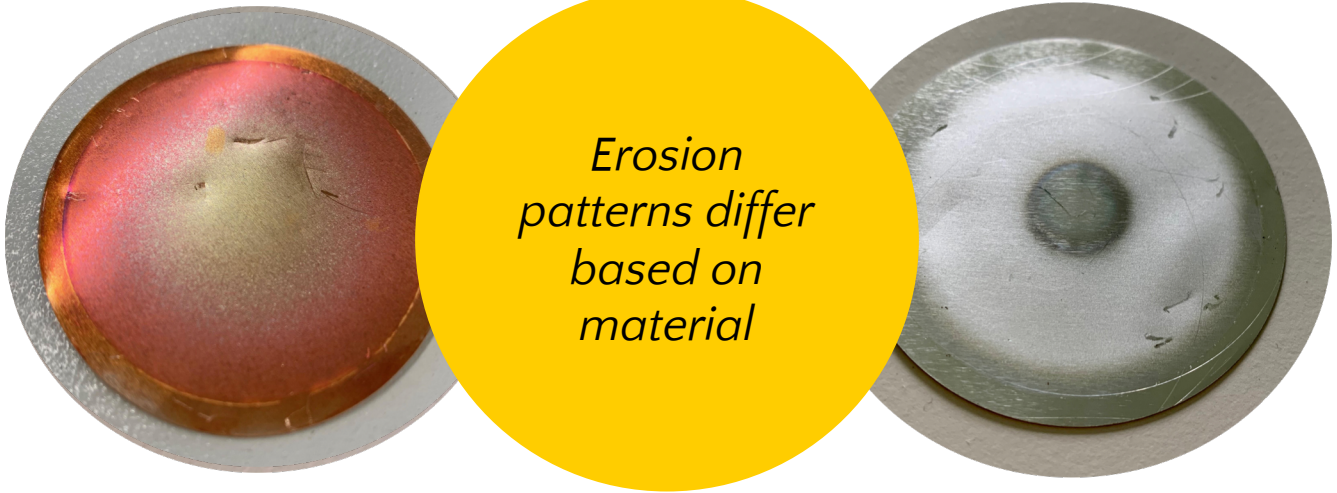
What was done?

- Different targets were sputtered using a small sputtering chamber

Why were experiments conducted?

- Track how erosion patterns change based on target material
- Predict how long a target could be used before becoming over-sputtered and worn out

Sputtering Results

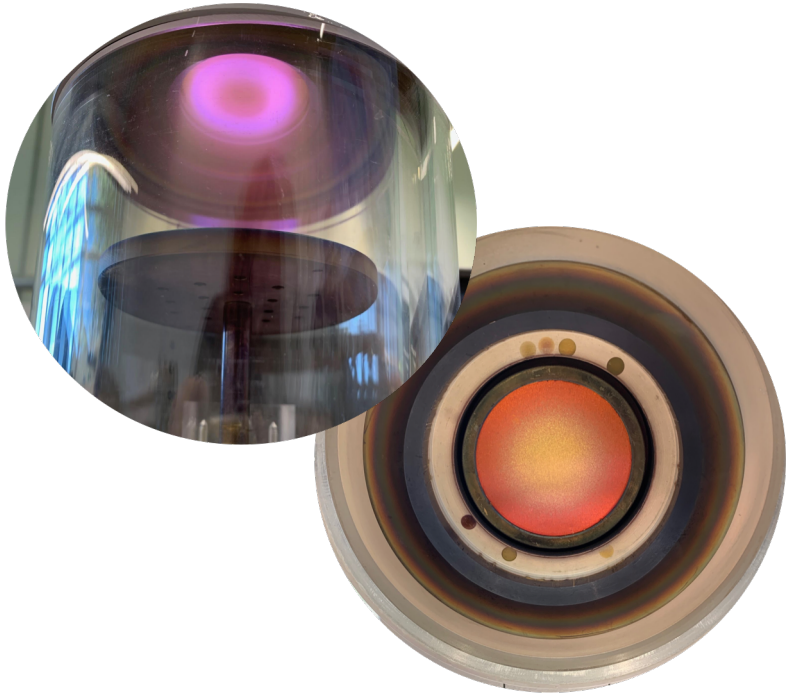


Erosion patterns differ based on material

Copper target after sputtering

Aluminum target after sputtering

Conclusions



Erosion patterns change based on:

- ☒ Particle energy
- ☑ Magnet strength/placement
- ☑ Target material

Future work:

- Use simulation to change magnet placement and strength
- Simulate ion-electron interactions
- Institute electron tracking in labs at NTB

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NTB
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