Particle Motion During Magnetron Sputter Deposition

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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

Uneven erosion

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
Electron density simulation

Electron paths

Magnetic field lines
Simulation Results

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