**Interface engineering of Mo/Si multilayers for enhanced reflectance in EUVL applications**

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**Coating facilities @ FOM**

- [Image of coating facility]
- **Properties**
  - Extended parameter range & collection of deposition techniques
  - Goal: Technology development for future Zeiss coaters & process exploration
  - Focus:
    - Lifetime: 30,000 hrs
    - Reflectivity: >80% (capped real optic)

**Deposition processes: principle layout of different process elements**

- Combines thermal, medium energy deposition, plasma & ion surface treatment
- TPM *method: precision deposition of ultra-thin film
  - deposition compounds
  - tunable energy of particles
  - Variable deposition geometry
  - Precision thickness control
  - ex-ray monitoring + quartz combined
- **TPM – thermalized particles magnetron**

**Available technologies**

- Combination of deposition with particles of different energy
- Barrier layer X at two interfaces
- Ion bombardment: atom mobility, reconstruction, formation of compounds

**Example of XPS analysis: B4C layer**

- [Graphs of XPS analysis]
- B4C compound in 4:1 stoichiometry can be obtained using both processes

**Example: E-beam deposition of B4C interlayers using X-ray monitoring**

- [Graphs of X-ray monitoring]
- X-ray monitoring allows to control growth of thin interlayers

**Best EUV reflectances**

- 70.5% @ 13.3 nm
- 70.15% @ 13.5 nm
- PTB data
- 1.5 degrees off-normal
- Barrier layer X at two interfaces

**Thermal stability Mo/X/Si/X**

- 100 °C, 24 hrs
  - No change is observed in ML properties around 100°C

**Conclusions**

- New e-beam and magnetron-based coating technologies allow interface engineering
- Reflectivities above 70% routinely obtained both by e-beam and magnetron sputtering
- Best value 70.5% @ 13.3 nm, 70.15% @ 13.5 nm
- Stress -250 MPa without stress compensation layer: considerably lower than earlier magnetron results on barrier layers (400MPa, M. Shrivast/ SPIE 2004-5374-11)
- First results on thermal stability preserving high reflectivity are very promising (~0.01 nm CTW @ 150 °C)
- BW approaches theoretical 0.55 nm value when using barrier layers

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**Example of stress analysis**

- Interferometry:
  - 0.2 nm B4C S=150 MPa
  - 0.4 nm B4C S=250 MPa

- Diffraction from Mo crystallites

- Diffraction in qualitative agreement with interferometry measurements

**Example of stress analysis**

- Current trade-off between reflectivity and stability shows possibility for improvement.