FOM-Institute for Plasma Physics Rijnhuizen

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

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Coating facilities @ FOM

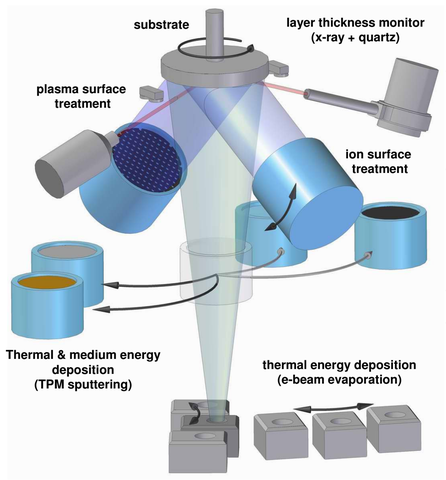
Properties

- *Extended parameter range & collection of deposition techniques*
- *Goal: Technology development for future Zeiss coaters & process exploration*
- *Focus:*
  - *Lifetime: 30.000 hrs*
  - *Reflectivity: >68 % (capped real optic)*

Analysis

- *in-vacuum XPS, AES, SEM*
- *in-vacuum STM (pending)*
- *low energy ion surface analysis*

Deposition processes: principle layout of different process elements

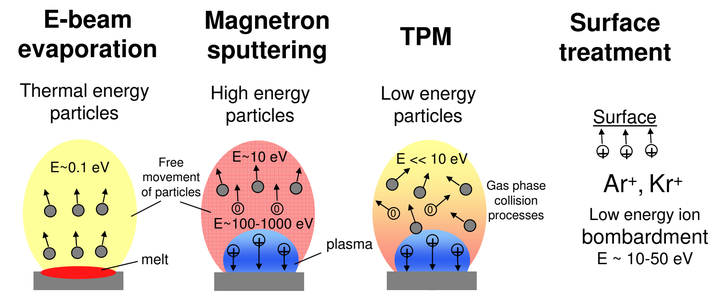


- *Combines thermal, medium energy deposition, plasma & ion surface treatment*
- *TPM * method*
  - *precision deposition of ultra-thin film*
  - *deposition compounds*
  - *tunable energy of particles*
- *Variable deposition geometry*
- *Precision thickness control*
  - *x-ray monitoring + quartz combined*

** TPM – thermalized particles magnetron*

Available technologies

Combination of deposition with particles of different energy



Thermal E particles: nucleation 1-2 monolayers of a new layer, avoiding intermixing

Higher energy particles: growth of the bulk layer

Ion bombardment: atom mobility, reconstruction, formation of compounds

Example of XPS analysis: B4C layer

E-beam

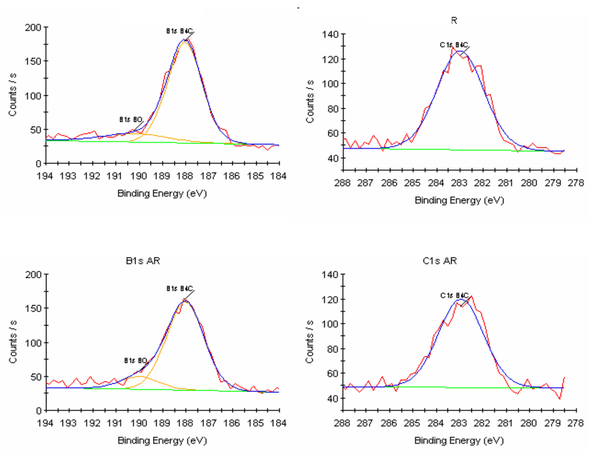
~4.0nm

4:1 B/C (B4C)

Magnetron

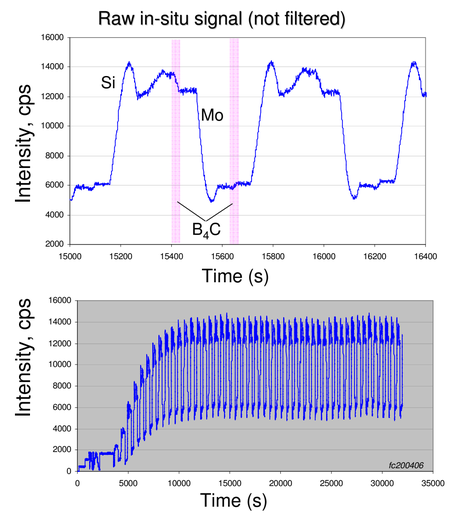
~4.0nm

4:1 B/C (B4C)



B4C compound in 4:1 stoichiometry can be obtained using both processes

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

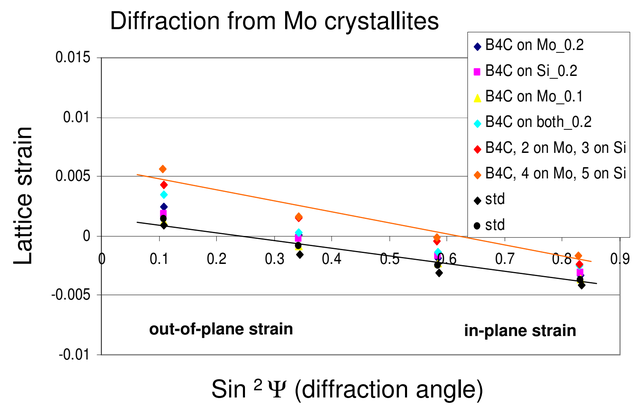


X-ray monitoring allows to control growth of thin interlayers

Example of stress analysis

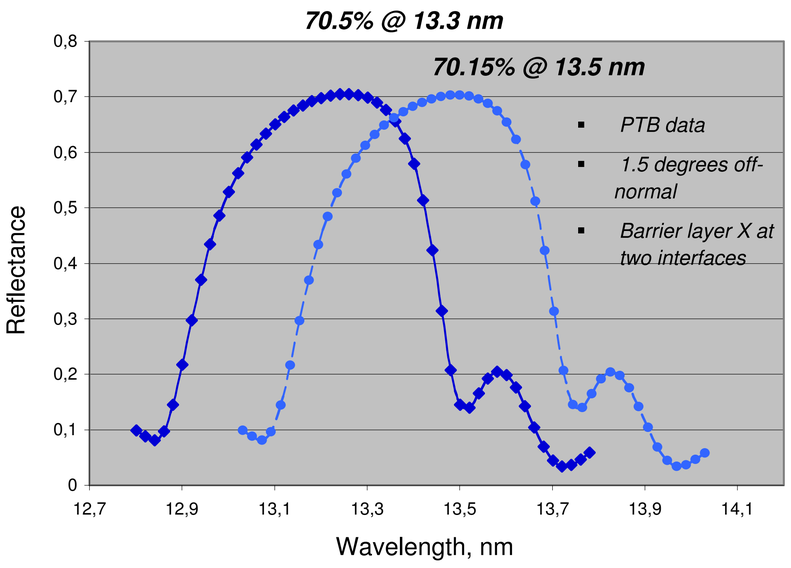
Interferometry:

- *0.2 nm B4C S=-150 MPa*
- *0.4 nm B4C S=-250 MPa*

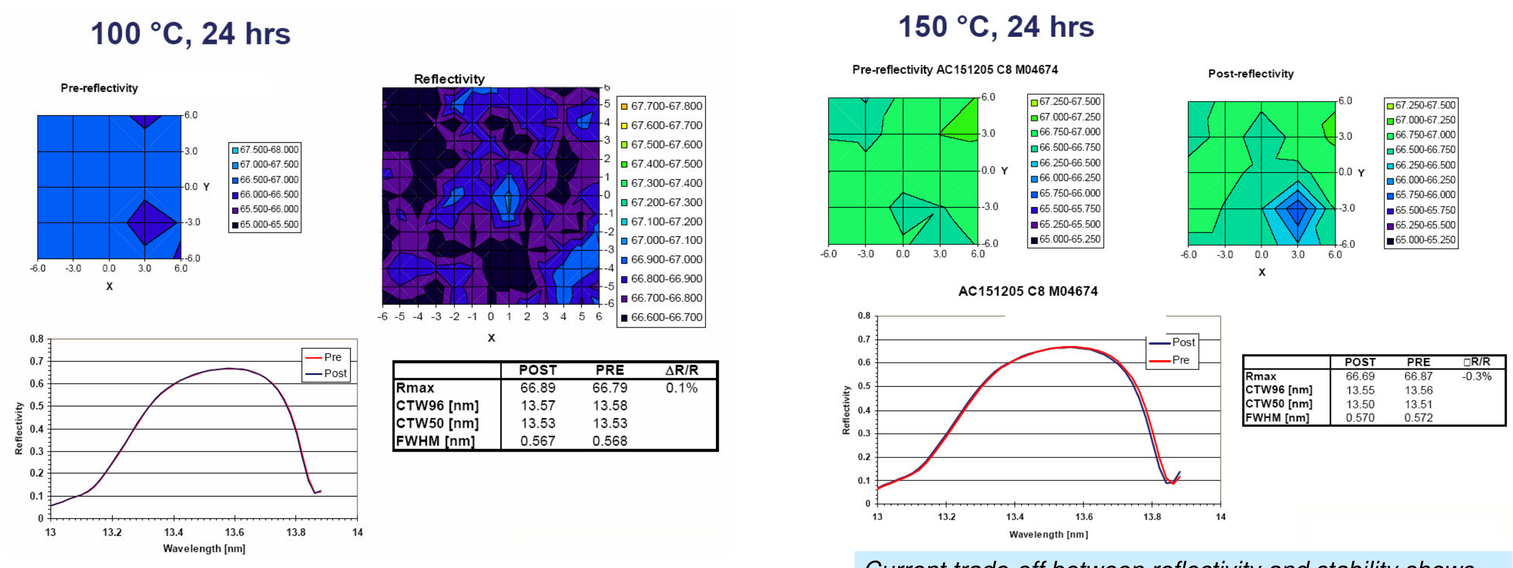


Diffraction in qualitative agreement with interferometry measurements

Best EUV reflectances



Thermal stability Mo/X/Si/X



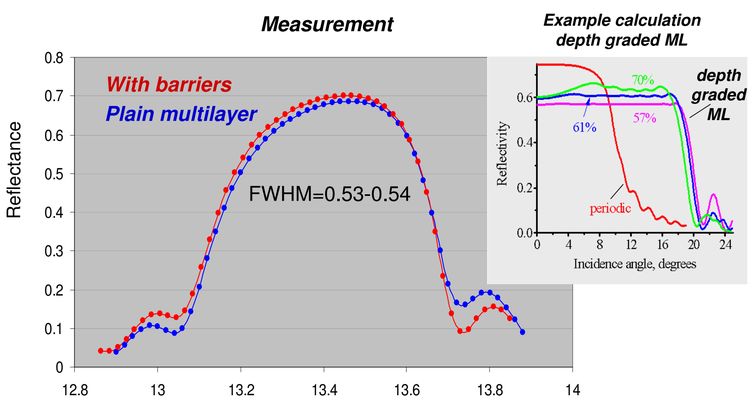
	POST	PRE	ΔR/R
Rmax	66.89	66.79	0.1%
CTW96 [nm]	13.57	13.58	
CTW50 [nm]	13.53	13.53	
FWHM [nm]	0.567	0.568	

	POST	PRE	ΔR/R
Rmax	66.69	66.87	-0.3%
CTW96 [nm]	13.55	13.56	
CTW50 [nm]	13.50	13.51	
FWHM [nm]	0.570	0.572	

No change is observed in ML properties around 100 °C

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

Bandwidth



Bandwidth slightly increases after introducing barriers, in agreement with calculations

Further broadening requires optimized stack designs
Ref: Kozhevnikov et.al, 6PXRMS 2002, Chamonix

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. Shiraishi 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*

Acknowledgments

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http://www. zeiss.de/
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