A Light for Science

European Synchrotron Radiation Facility

Modifications of coherent hard X-rays beams induced by reflection on multilayer mirrors

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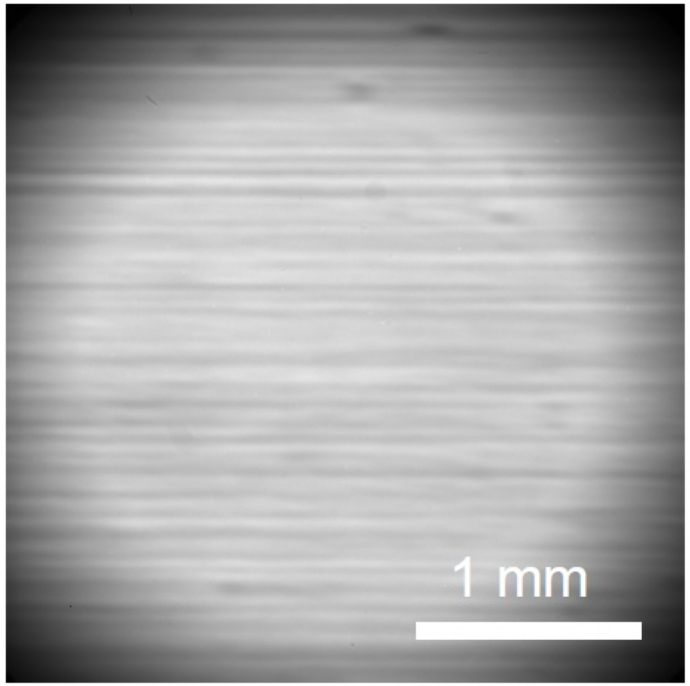
Th. Holz, A. Cecilia, A. Vivo, T. Weitkamp,
M. Osterhoff, H. Riesemeier, P. Cloetens, E. Ziegler,
L. Assoufid, B. Shi, R. Conley

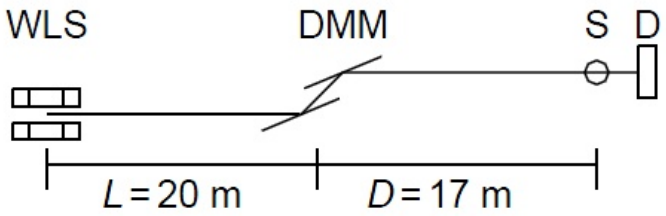


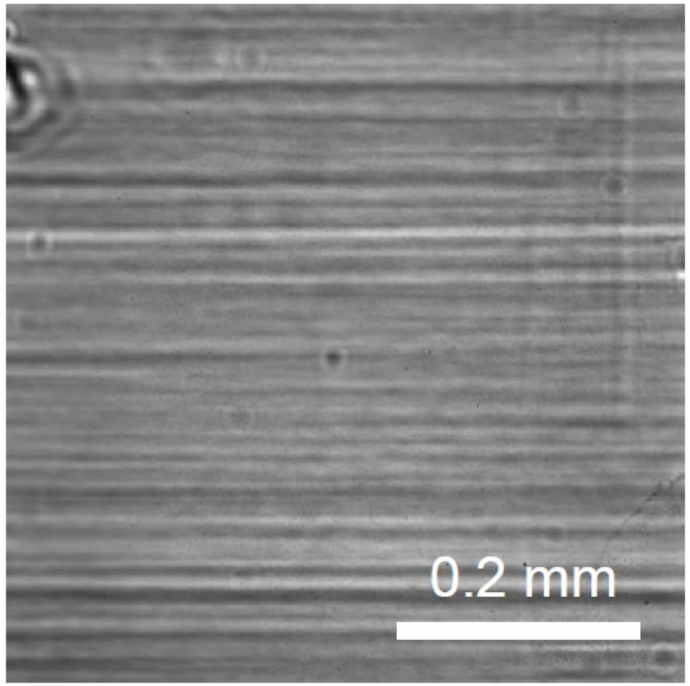
European Synchrotron Radiation Facility

Beam Profile – „The Stripes“

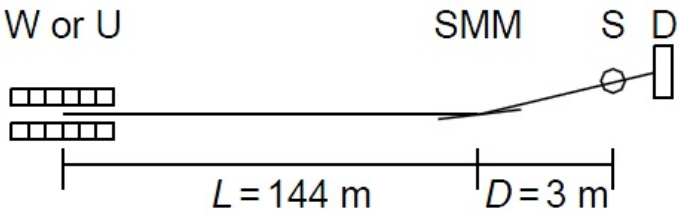


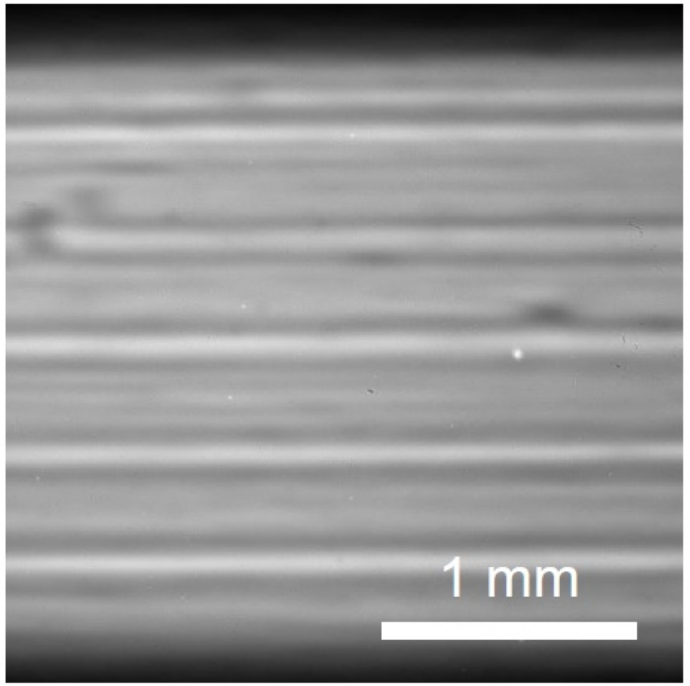
BESSY–II / BAMline



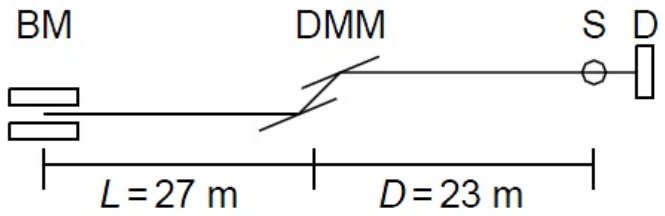


ESRF / ID19





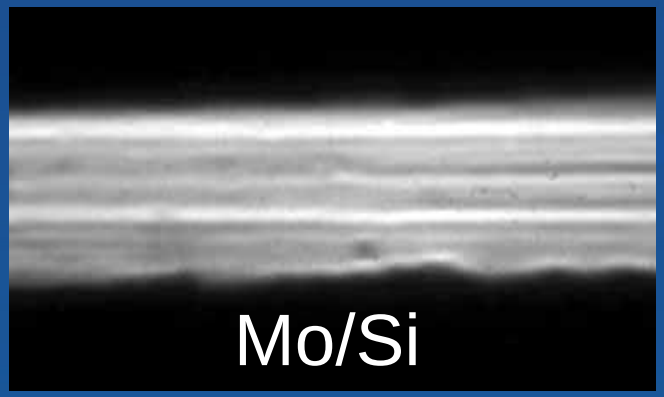
APS / 2–BM

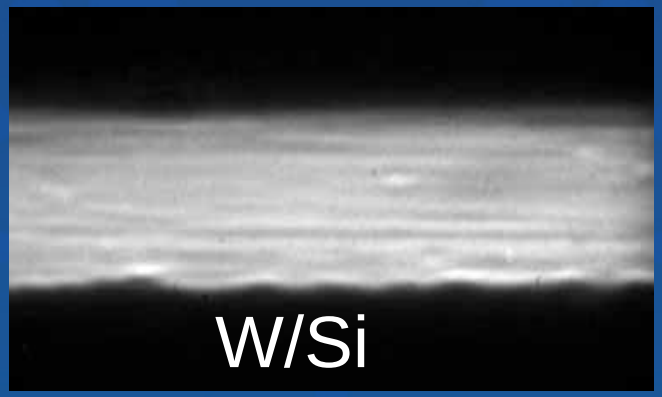


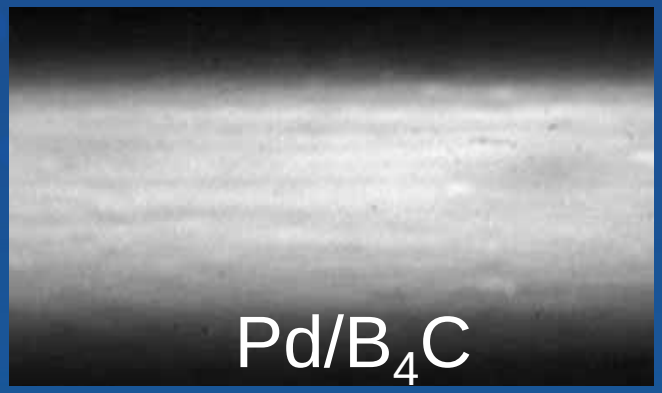
Rack et al., JSR 17 (4) 2010

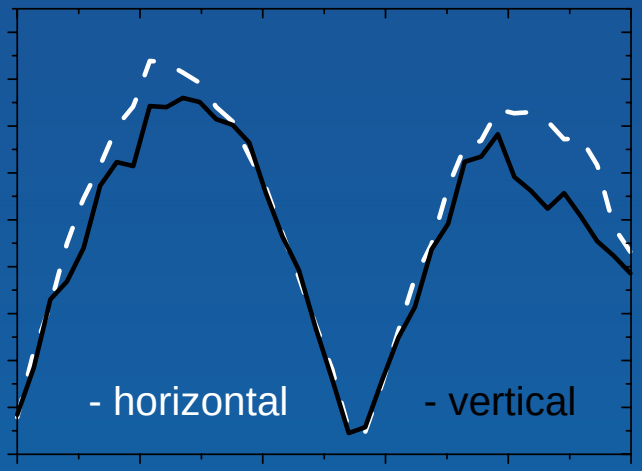
Multilayers vs. Wavefront

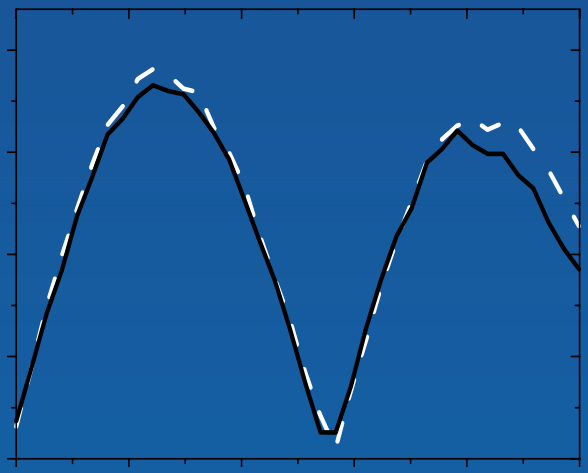
First Wavefront Preservation Study

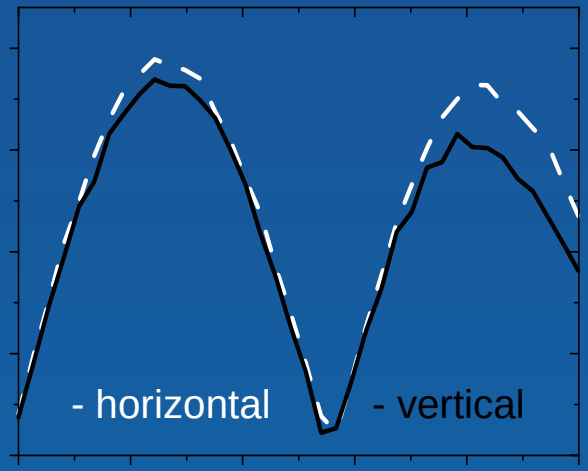




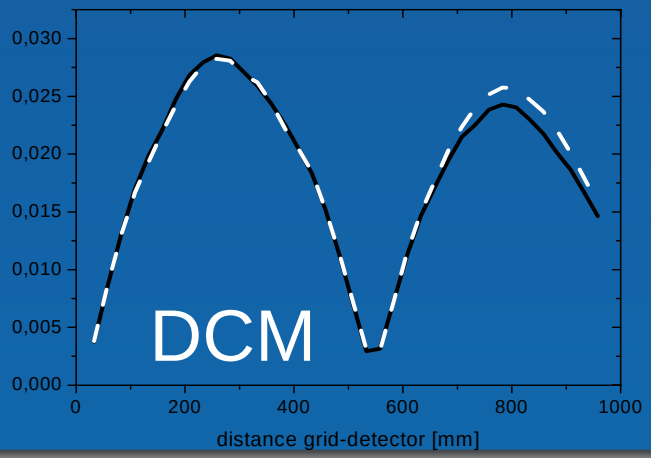








- similar substrate roughness (F. Siewert - BESSY), 1“ dia.
- similar surface layer as well as interlayer roughness (XRR)
- coatings: AXO Dresden GmbH

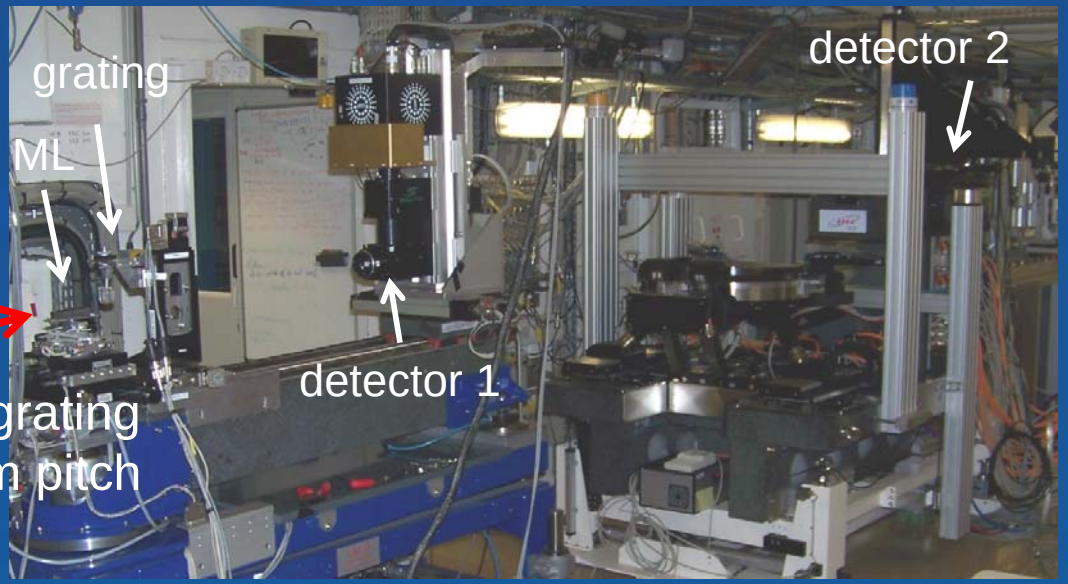


- similar spatial resolution reachable
- different coherence properties
- different stripe patterns

Rack et al., JSR 17 (4) 2010

Protocol: Wavefront Preservation Studies

Imaging detector 2
0.75 µm pixel size
FReLoN e2v with “old 1 µm” ,
10x/03. NA, 20 µm GGG:Eu



phase grating
Si, 6 µm pitch

Imaging detector 1
0.7 µm pixel size
FReLoN 2k w/OP ID19
revolver, 10x/03. NA, 4.5 LSO

multilayer
on sample
manipulator

DCM (Si111)
18 keV

2x U32 undulator
“250 µm x 50 µm”
4-bunch mode

95 … 844 mm

147 m

185 mm

7 m

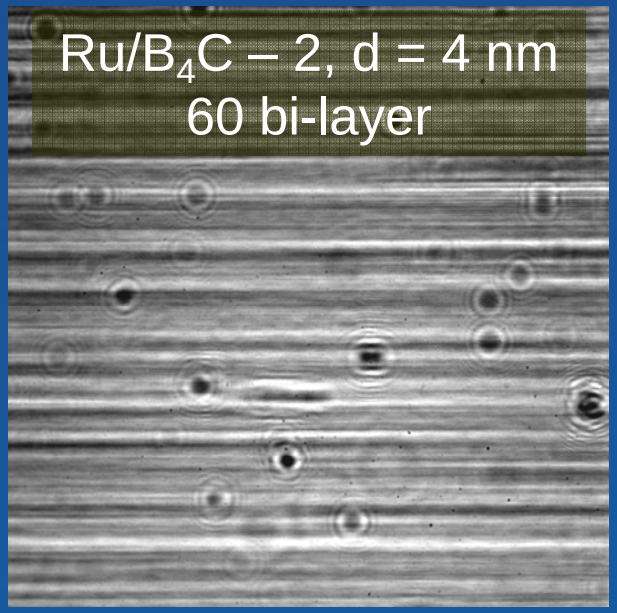
140 m

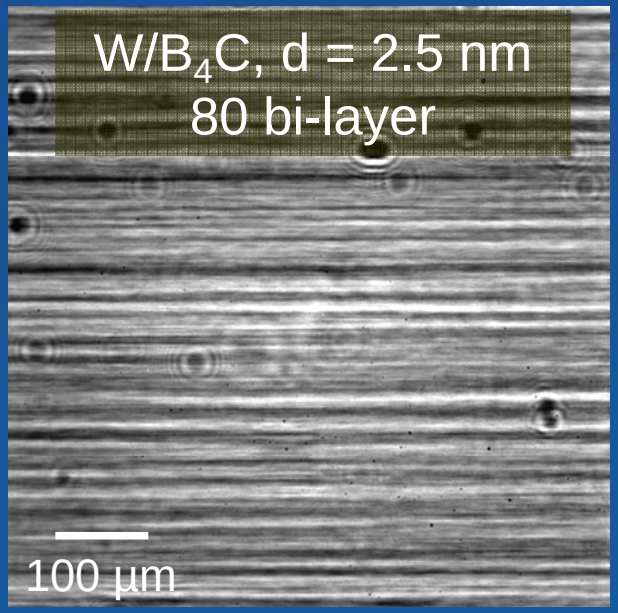
6.1 m

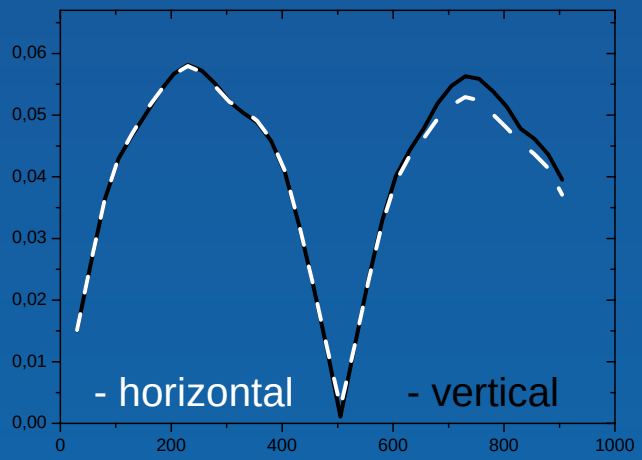
Open for beamtime application proposals!

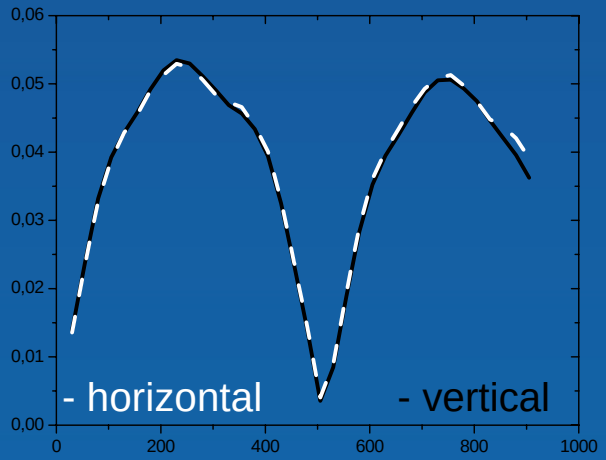
cf. Weitkamp et al., AIP Proc. 1221, 2010
Rack, Weitkamp et al., NIMA, in prep.

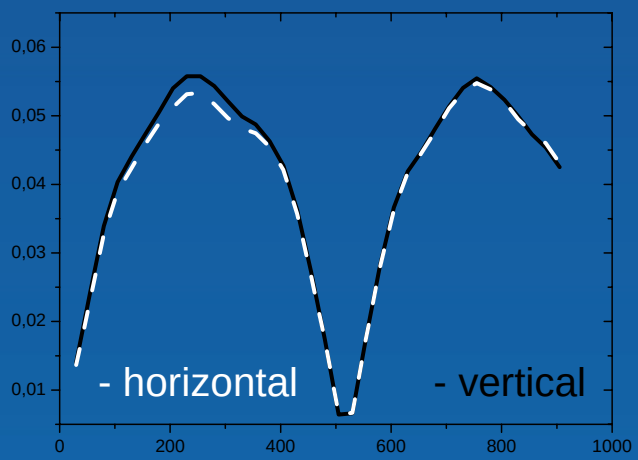
Extension Towards Larger Mirrors



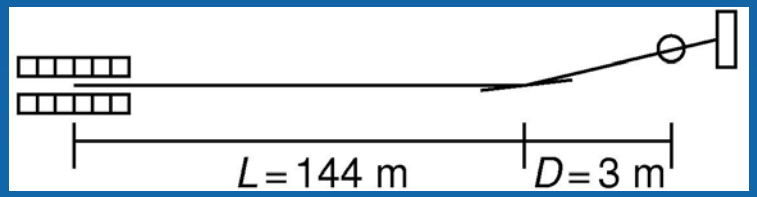








E = 18 keV
0.35 µm pixel size



Rack, Weitkamp et al.
NIMA 649 (2011)

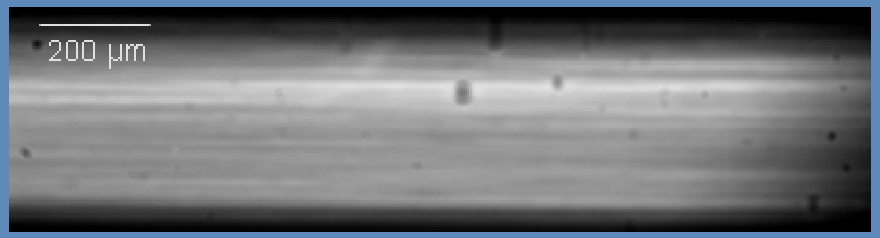
Beamline Round-Robin: APS & ESRF

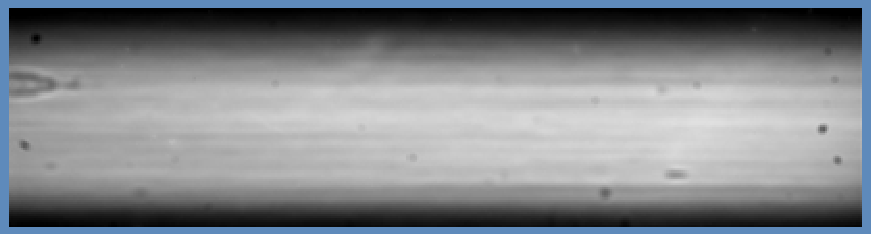
APS (32-ID)

ESRF (ID19, BM5)

Beam Profile

32-ID





Mo/Si

2.5 nm d-spacing

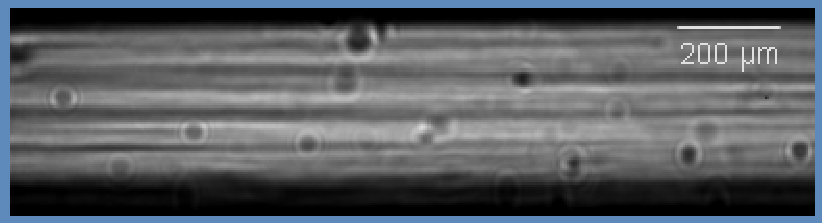
220 bi-layers

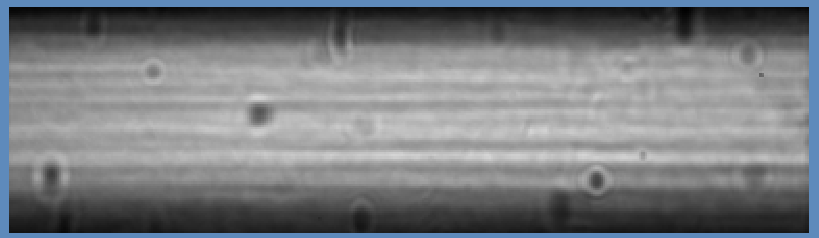
Pd/B_4C

2.5 nm d-spacing

220 bi-layers

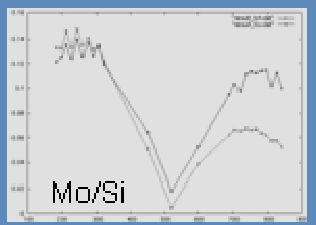
ID19

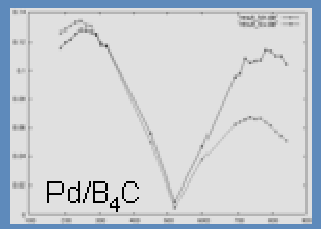




Coherence Preservation

32-ID





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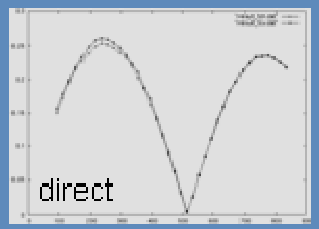
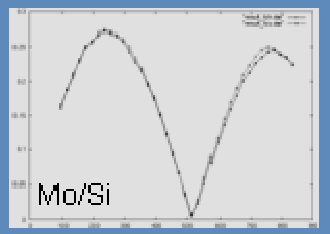
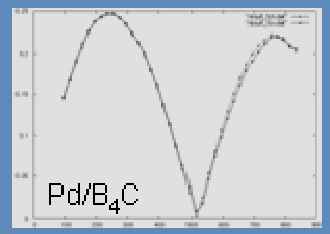


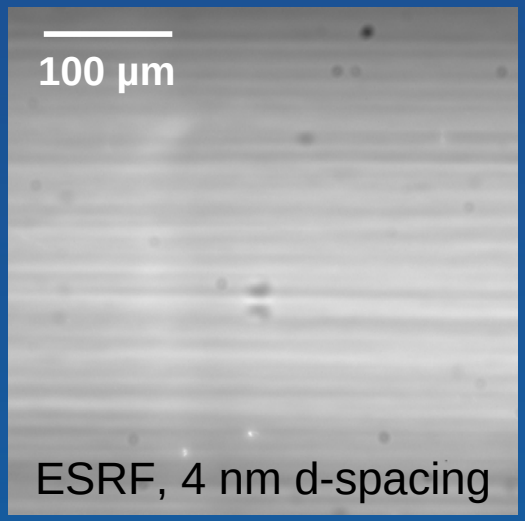


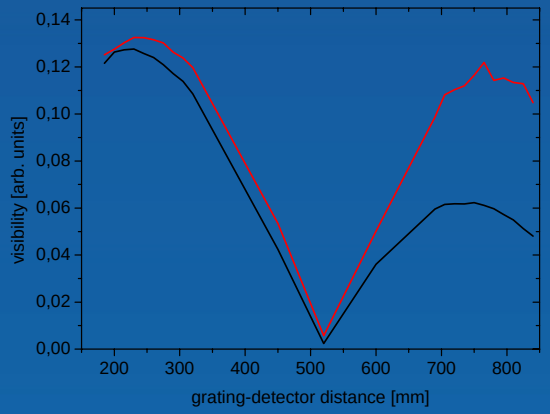


Rack, Assoufid et al.
AIP Conf Proc 1437 (2012)

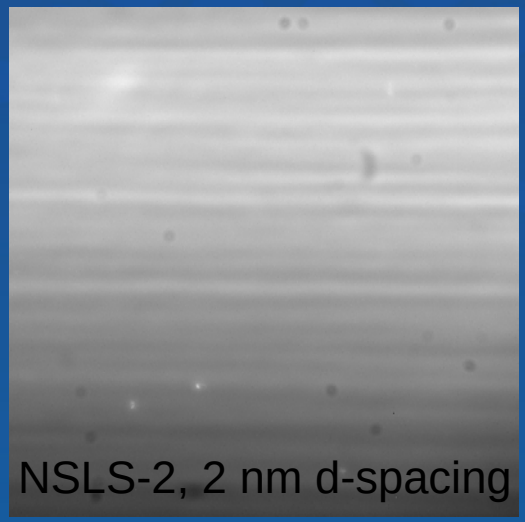
Deposition Facility Round-Robin

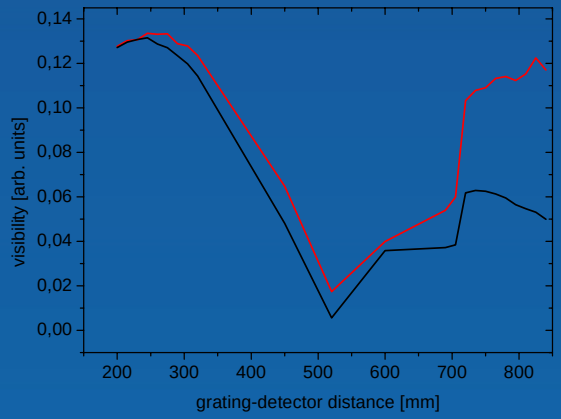
ESRF



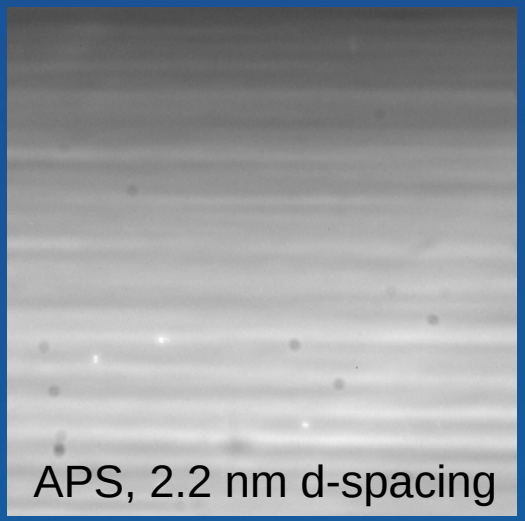


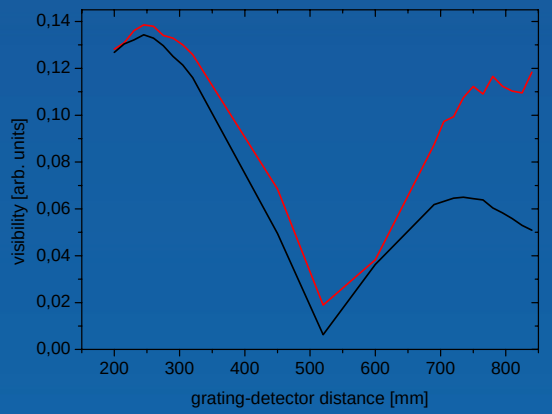
NSLS-2





APS



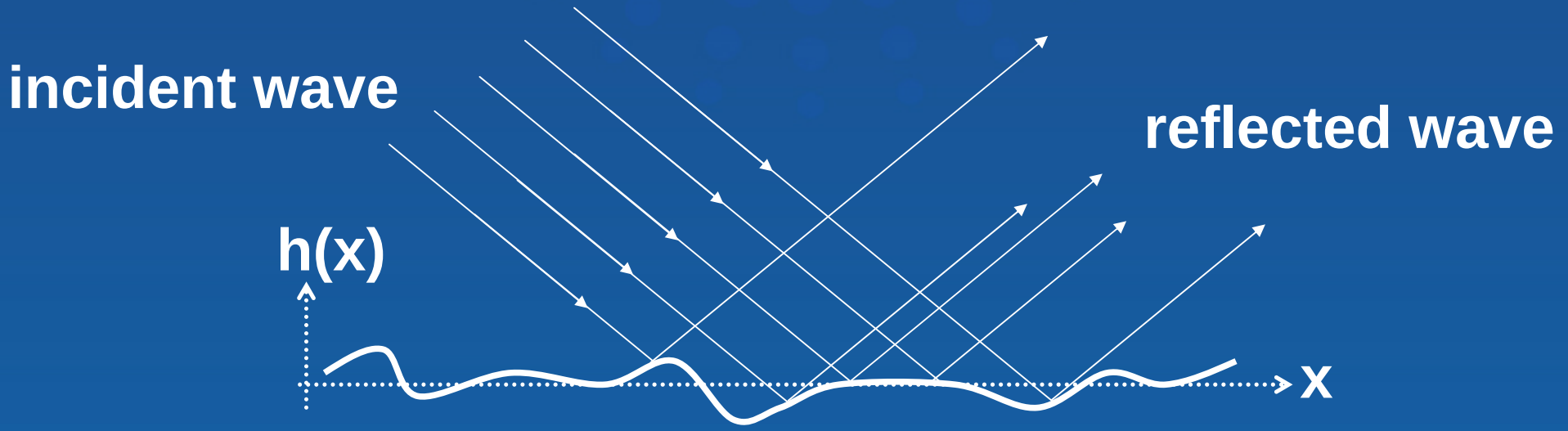


W/B_4C, study @ 32-ID (APS)

Rack, Assoufid et al.
Rad Phys Chem, in press (2012)

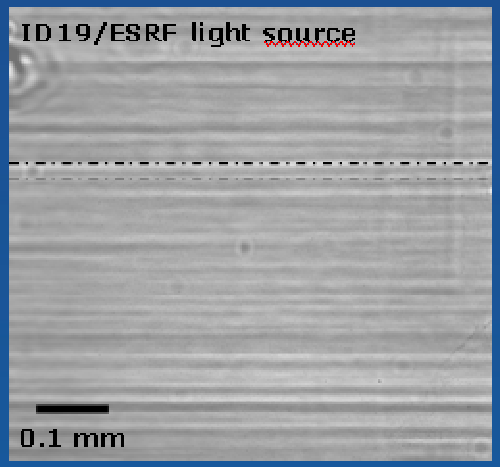
The Substrate

Model



E. Ziegler, et al., Japan Soc. Precision Engin. Proc. Vol. 3 (1999)
Rack et al., JSR 17 (2010)
Cocco et al., NIMA 616 (2010)
Siewert et al., Opt. Expr. 20 (2012)

Multilayer Monos Around The Globe



W/U ◄144 m► SMM ◄3 m► EXP

source: 135 µm x 25 µm (h x v)
FWHM
18 keV

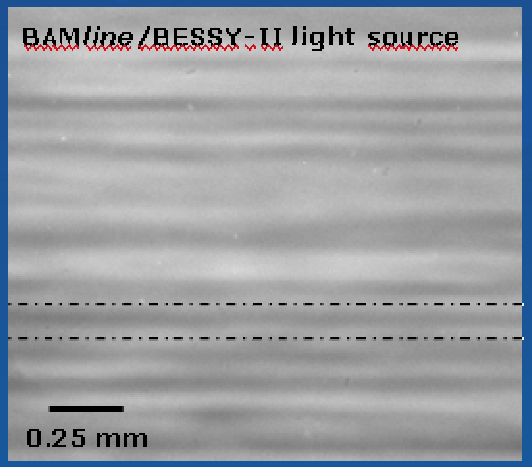
3.92 nm d-spacing
Ru/B_4C

Measured period: 25 µm

calculated period with most contrast: 21 µm

blur: 1 µm

length scale on multilayer surface: 2.3 mm



WLS ◄20 m► DMM ◄17 m► EXP

source: 164 µm x 40 µm (h x v)
FWHM
18 keV

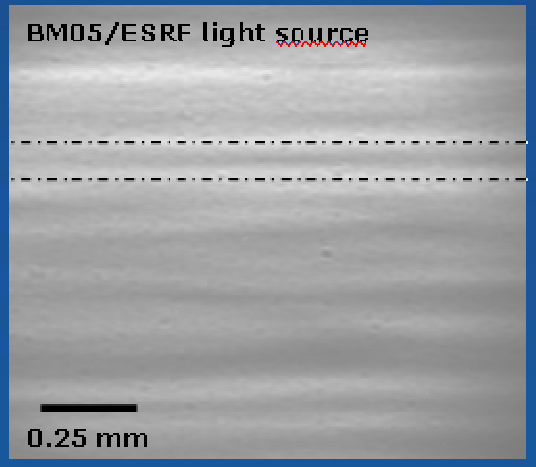
2.88 nm d-spacing
W/Si

Measured period: 90 µm

calculated period with most contrast: 66 µm

blur: 34 µm

length scale on multilayer surface: 3.0 mm



BM ◄28 m► DMM ◄13 m► EXP

source: 270 µm x 80 µm (h x v)
FWHM
20 keV

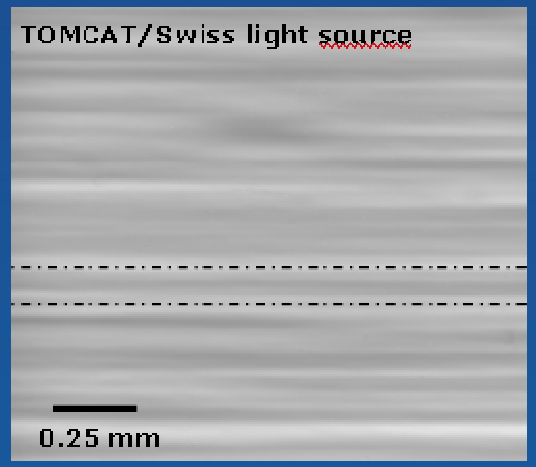
4.0 nm d-spacing
Ru/B_4C

Measured period: 85 µm

calculated period with most contrast: 49 µm

blur: 37 µm

length scale on multilayer surface: 4.3 mm



BM ◄7 m► DMM ◄18 m► EXP

source: 53 µm x 16 µm (h x v)
SIGMA
15 keV

4.0 nm d-spacing
Ru/C

Measured period: 130 µm

calculated period with most contrast: 103 µm

blur: 82 µm

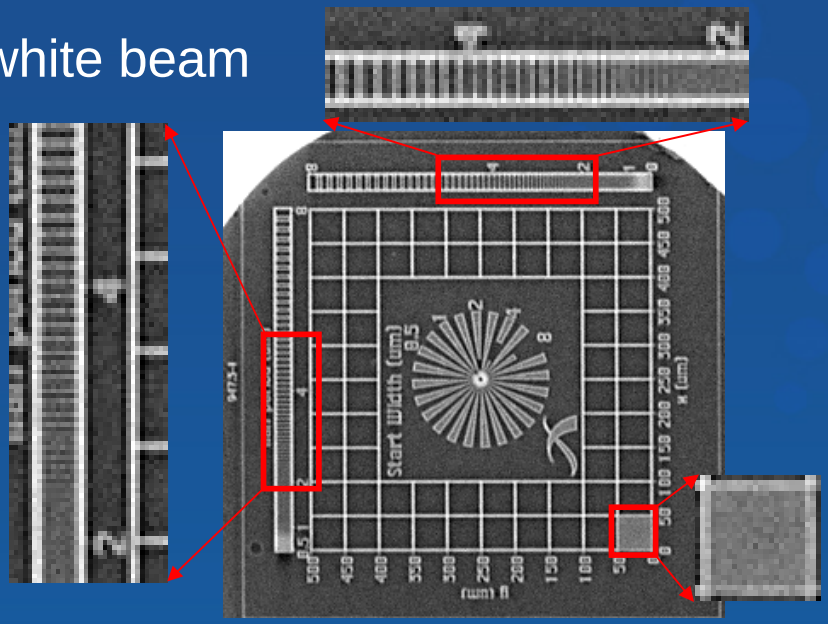
length scale on multilayer surface: 2.8 mm

Rack, et al., Opt. Express, in prep.

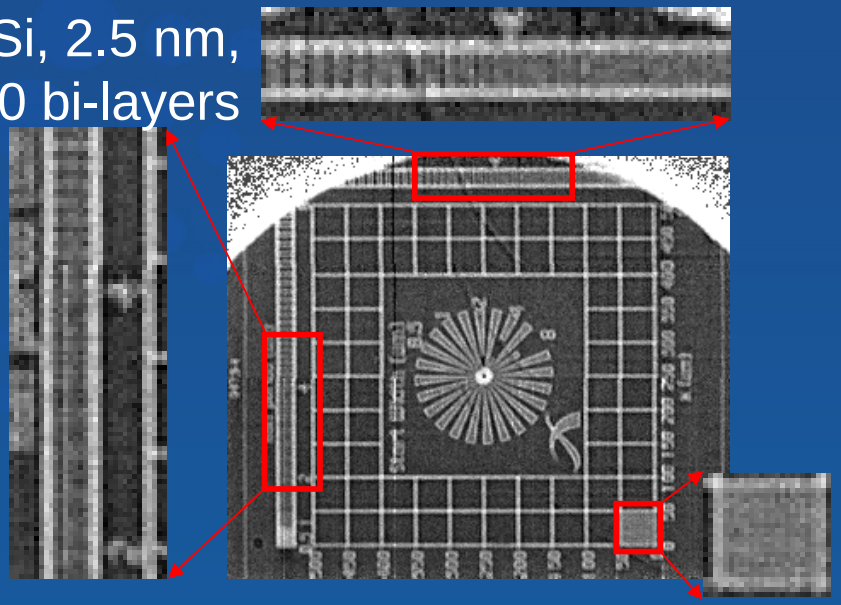
Coherence or Coherence?

Full-field Micro-Imaging

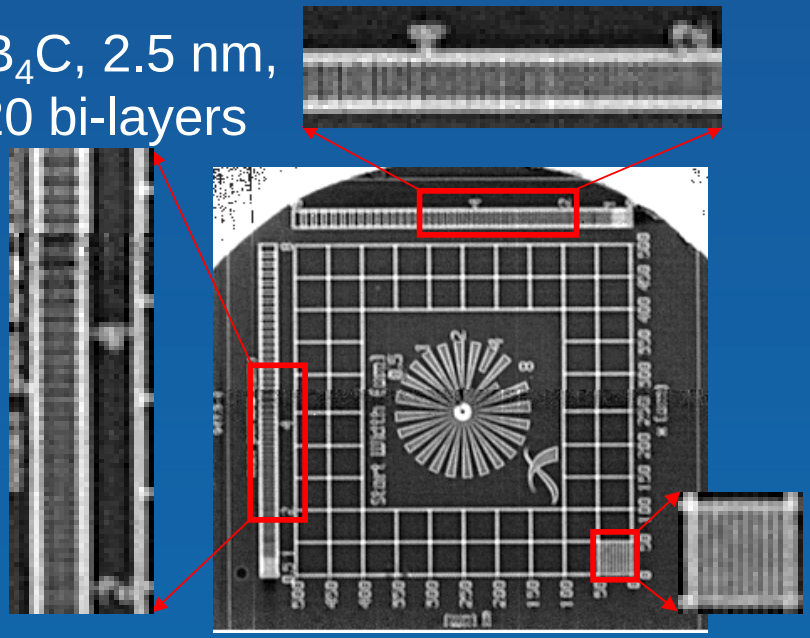
white beam



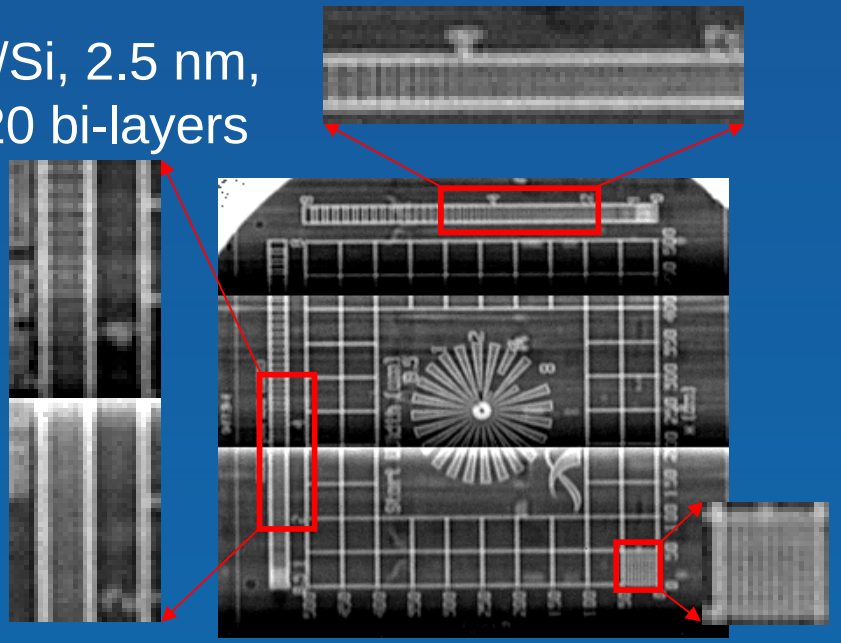
W/Si, 2.5 nm,
120 bi-layers



Pd/B_4C, 2.5 nm,
220 bi-layers



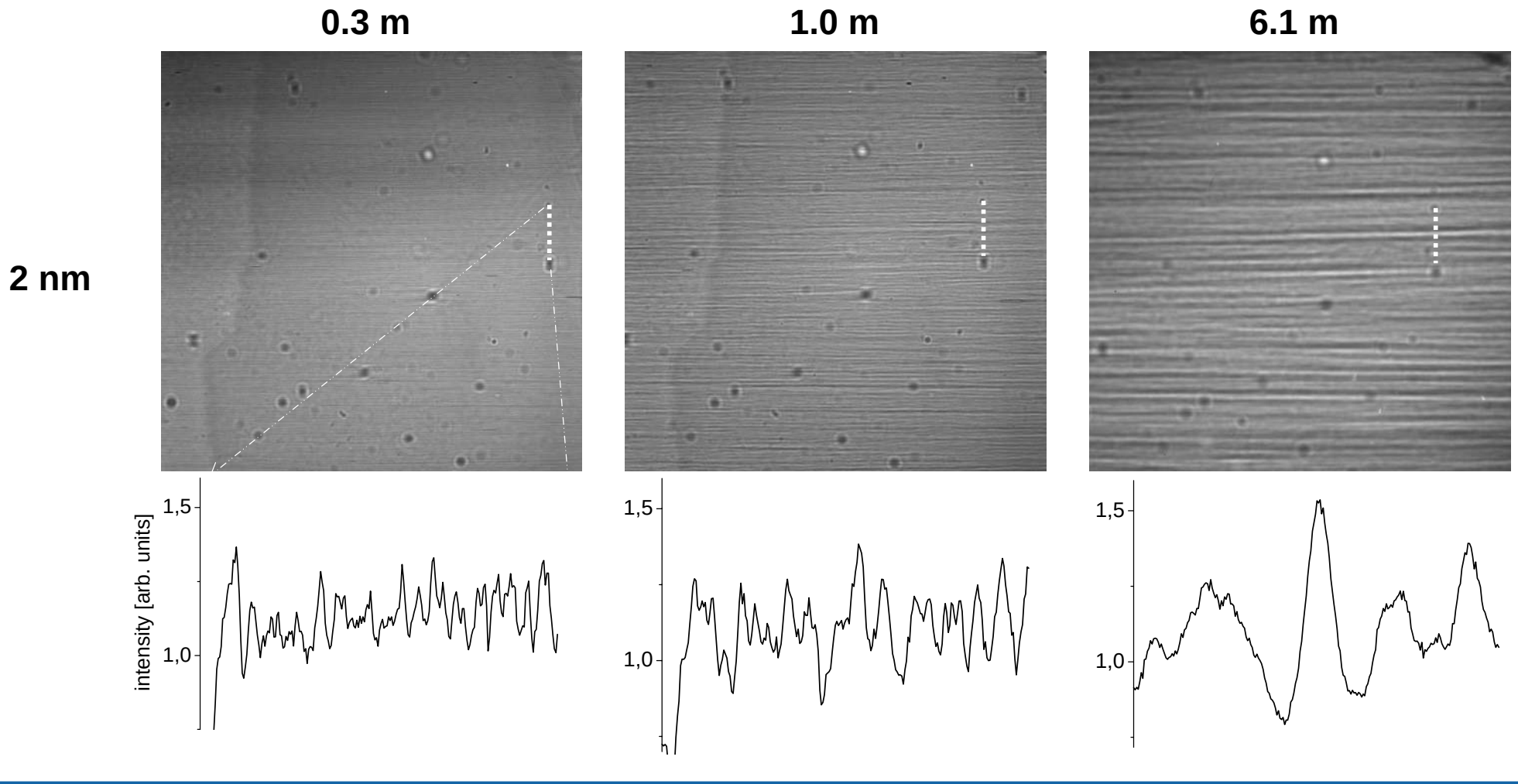
Mo/Si, 2.5 nm,
220 bi-layers



E =
18 keV

Rack et al., JSR 17 (4) 2010

Beam Profile @ ID19



W/B_4C, E = 18 keV

Rack, et al., Opt. Express, in prep.

Summary

Known:

- degradation of the wavefront due to reflection on multilayer mirrors
- stripe pattern if visible related to the substrate
- full-field imaging requires wavefront preservation, i.e. coherence and homogeneity
- parameters like number of layers, d-spacing, deposition facility minor influence, characteristics are reproducable, see different beamlines

Unknown:

- why some multilayer mirrors outperform (Pd/B_4C – AXO Dresden GmbH)

Next steps:

- progress towards production of specified multilayers before performing the characterisations (roughness, coating composition)
- focus on the substrate: suppliers, figure error
- deterministic model (PhD)

Thanks for your attention!

Rack, Weitkamp et al., J Synchrotron Radiation vol. 17, no. 4 (2010)

Rack, Weitkamp et al., NIMA 649 (2011)

Rack, Assoufid et al., Radiat Phys Chem, in press (2012)

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