Optics Testing at a Repurposed Beamline: 1-BM

Albert Macrander

APS/User Operations Monthly Meeting, Nov. 20, 2013

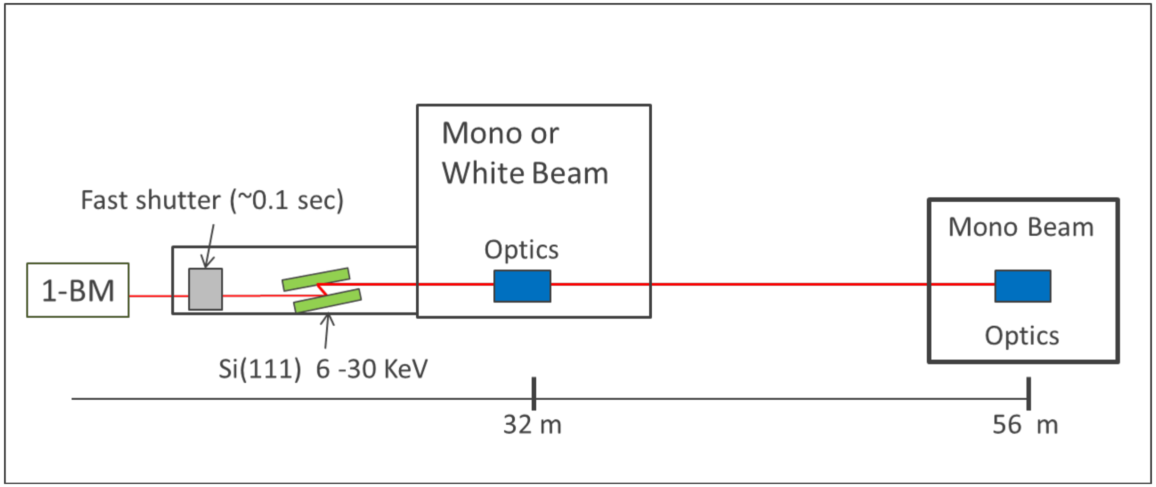
Optics and Detector test beamlines worldwide

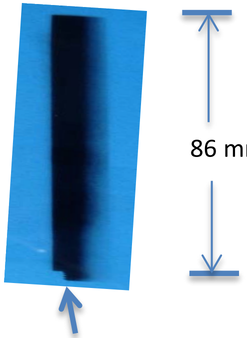
This is a representative list, rather than a complete one

- Diamond Light Source, Oxfordshire, UK: bend B-16 "Test beamline" http://www.diamond.ac.uk/Home/Beamlines/B16.html
- ESRF, Grenoble, France: bend BM05 "Instrumentation Facility" http://www.esrf.eu/UsersAndScience/Experiments/Imaging/BM05
- Swiss Light Source, Villigen, Switzerland: bend X05DA "Optics Test Beamline" http://www.psi.ch/sls/optics/optics
- Petra III Extension, Hamburg, Germany: P21.5 "Education, Training and Testing End Station" http://petra3-extension.desy.de/e84814/e86697/
- BESSY II, Berlin, Germany: PTB-Laboratory with nine experimental stations including characterization of optical components http://www.ptb.de/mls/aufgaben/bessylab.html
- SSRL, Stanford, USA: bend 2-2 "White light station" http://www-ssrl.slac.stanford.edu/beamlines/bl2-2/
- ALS, Berkeley, USA: bend 5.3.1 "Instrumentation development" http://www-als.lbl.gov/index.php/beamlines/beamlines-directory/104-531.html
- NSLS, Upton, USA: bend U3C "Livermore metrology" http://beamlines.ps.bnl.gov/beamline.aspx?blid=U3C

→ **+ APS Beamline 1-BM**

Optics and Detector Testing Beamline: 1-BM





Sapphire(0006), 8keV

- Strongly recommended in Sept. 2011 DoE review of APS.
- Frequent, brief access on a stable setup needed for developmental efforts: this is difficult to achieve on most other beamlines, which require science-based general user proposals that are often scheduled in one time period over four months.
- Crystal optics testing: topography- both monochromatic and white beam - for APS crystal optics development and for user community presently based at NSLS . Also for Industrial Users (Rubicon Technology, Inc.) .
- Talbot interferometry for coherence length measurements.
- IXS analyzer testing: polarization selection, spherical backscattering
- Mirror testing: K-Bs, adaptive, radiation damaged.
- Zone plate testing: MLLs, FZP
- 5 GUP proposals submitted for 2013-3, 6 new GUP proposals for run 2014-1 .

Acknowledgements

Optics Group:

Naresh Kujala
Shashidhara Marathe
Xianbo Shi
Xianrong Huang
Bing Shi
Ray Conley
Lashen Assoufid

Detector Group:

Robert Bradford
Matt Moore
Russell Woods
Lisa Gades

Sector 1 (EDD):

Ali Mashayekhi
John Okasinski
John Almer

Optics Mounting:

Deming Shu

IXS polarization selection analyzers:

Clem Burns (Western Michigan)
Xuan Gao (Western Michigan)

IXS analyzers:

Jerry Seidler (Univ. Washington)
Joe Pacold (Univ. Washington)

IXS analyzers:

Ayman Said
Thomas Gog
Diego Casa

Topography users/collaborators:

John Ciraldo (Rubicon Tech.)
Michael Dudley , Balaji Raghothamachar ,
and students(Stonybrook Univ.)
Stan Stoupin & Yuri Shvyd' ko

Grating Fabrication for Talbot Interferometry and FZP studies:

Derrick Mancini
Michael Wojcik

Adaptive Mirror Studies:

Frank Landers (Northrop Grumman)
Richard Egan (Northrop Grumman)
Kevin Ezzo (Northrop Grumman)
Ali Khounsary

Beamline controls:

Kurt Goetze
Joe Sullivan
Jeff Kirchman

Beamline reconfiguration:

Mark Erdmann
Scott Wesling
Dan Nocher

XSD:

Mark Beno
Jonathan Lang
Chris Jacobsen
Linda Young

Industrial User Liason:

Jyotsana Lal

MLL Studies:

Hanfei Yan (NSLSII)
Jorg Maser
Adam Kubec
Nathalie Boutet (NSLSII)
Deming Shu

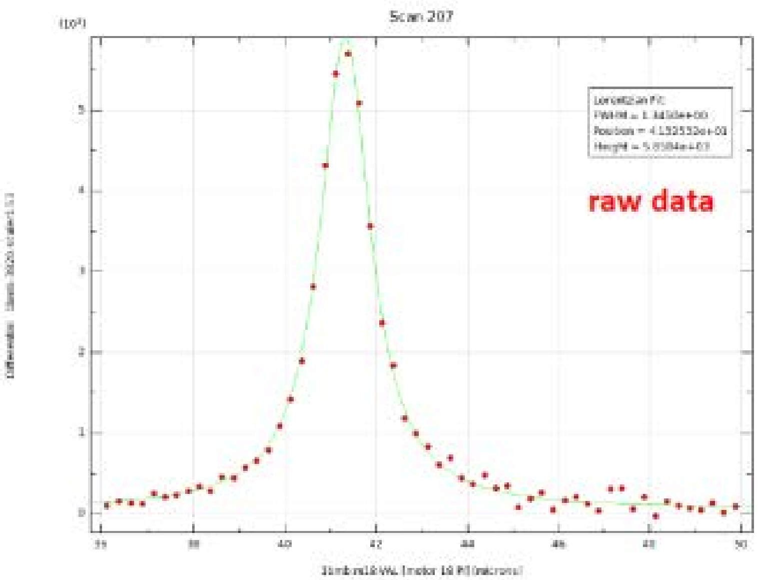
Test Results of a Prototype K-B Mirror Assembly for 8-BM

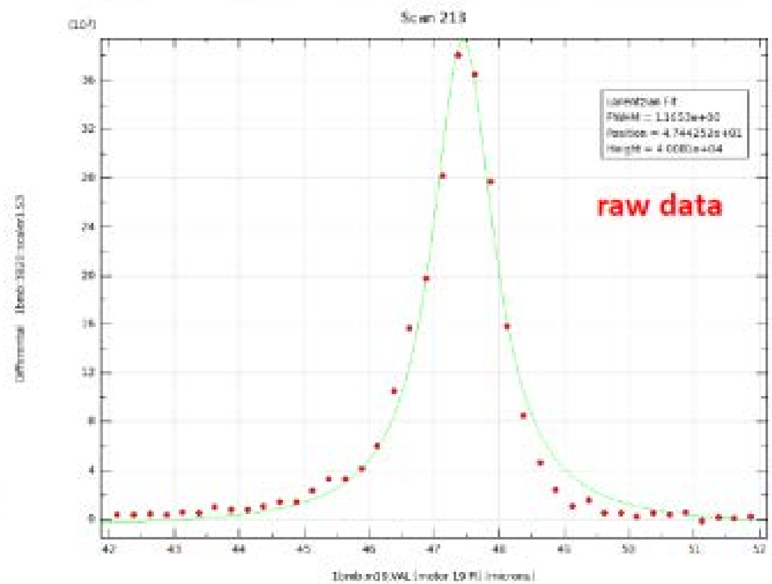
XSD/OPT Group , March 4, 2013

- Elliptical mirrors fabricated by profile coating
  - Spec. : 1 µm x 1 µm focus
  - Vertical focusing mirror (VFM): 70 mm, Horizontal focusing mirror (HFM): 60 mm
  - Substrates: Si, Coating material: Pt
- Mounting assembly design by D. Shu
- Tests carried out at 1-BM using 18 keV x-rays

- Demagnification of ~124
- Vertical source size =110 µm
- Geometrical focus ~ 0.89 µm
- Diffracted-limited size <200 nm

Measured 2-D focus size (raw data):
~1.2 µm (H) x 1.3 µm (V) (Spec. : 1 µm x 1 µm)





"Testing of elliptical Kirkpatrick-Baez mirrors focusing optics for hard X-rays at the beamline 1-BM of Advanced Photon Source", Naresh G Kujala, Shashidhara Marathe, Deming Shu, Bing Shi, Jun Qian, Lydia Finney, Chris Jacobsen, Albert T Macrander, and Lahsen Assoufid*, in preparation.

Topography Applications

Monochromatic Beam

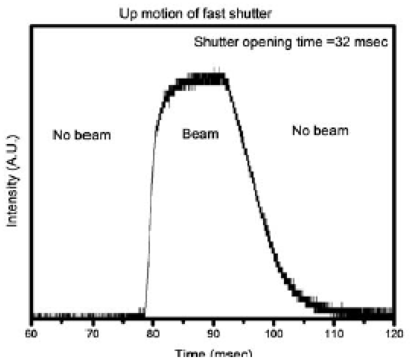
Image sources of strain that broaden rocking curves of (hkl) reflections.

Application to sapphire , GaN/sapphire, 6H-SiC, 4H-SiC, epitaxial doped Si.

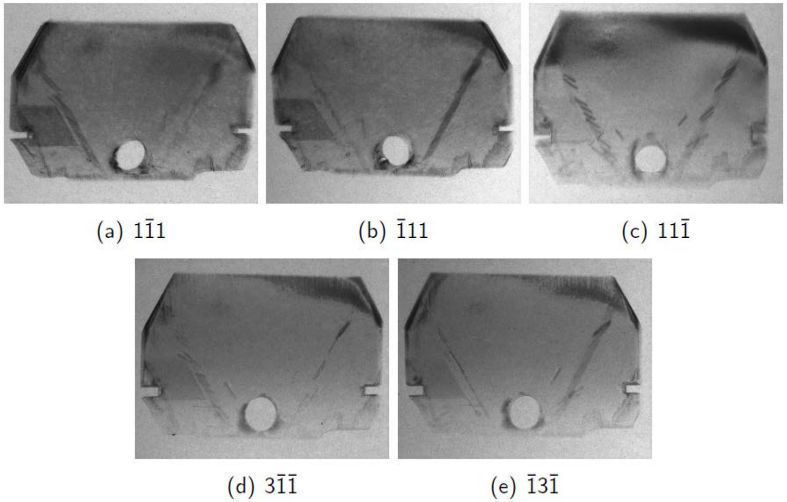
White Beam

Image defects in many reflections at once. Heat load deformations can occur for poor thermal conductors (exposures > 50 msec for sapphire).

Example application: type IIa <111> diamond from TISNCM



200 msec exposure found to have best contrast



S. Stoupin & Y. Shvyd'ko, Nov. 2013

ENERGY SYSTEMS SEMINAR

Thursday December 12, 2013, 2:00 PM

Bldg. 362 Room F-108

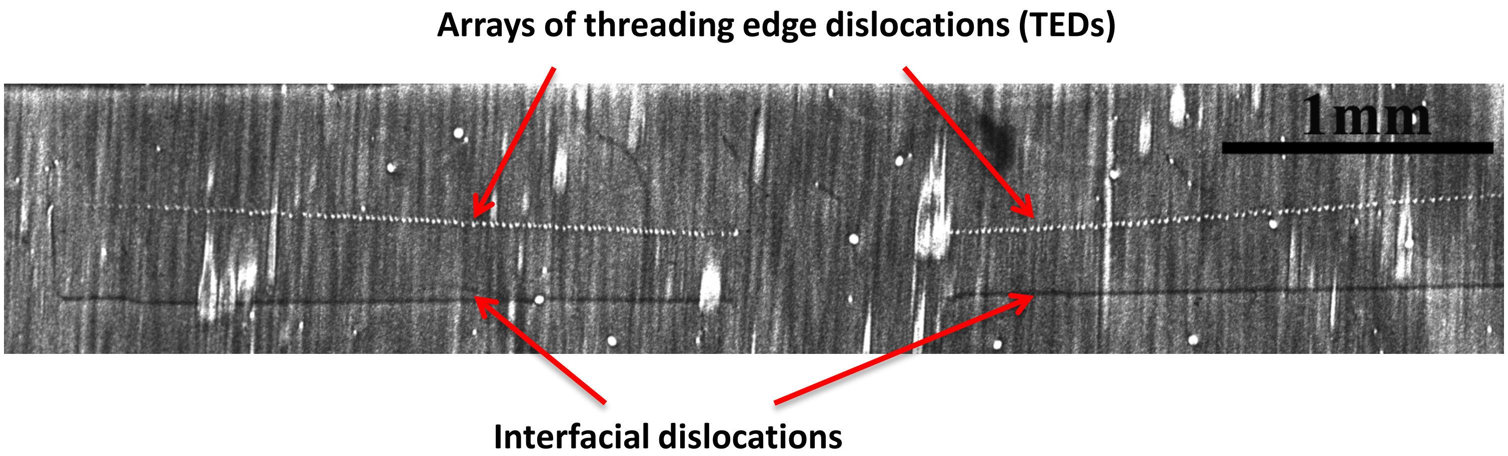
Analysis of Defects in Physical Vapor Transport Grown 4H-SiC Substrates and Chemical Vapor Deposition Grown Homo-Epitaxial Layers Using Synchrotron X-ray Topography

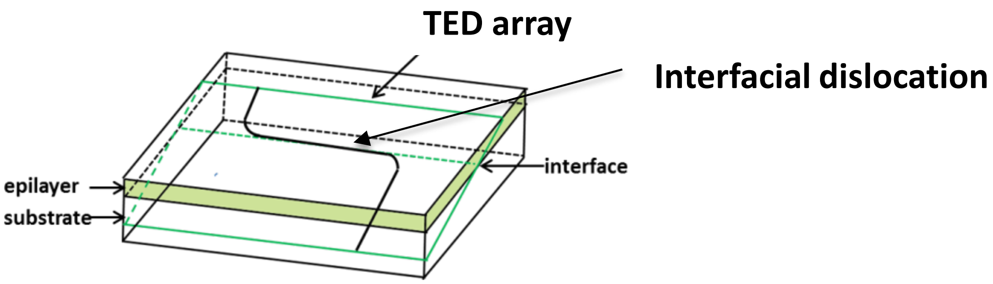
Prof. Michael Dudley

Dept. of Materials Science & Engineering, Stony Brook University, Stony Brook NY 11794-2275

Monochromatic grazing incidence topography on etched 4H-SiC wafer done in 1-BM-C

M. Dudley, B. Raghothamachar, and students, June 2013





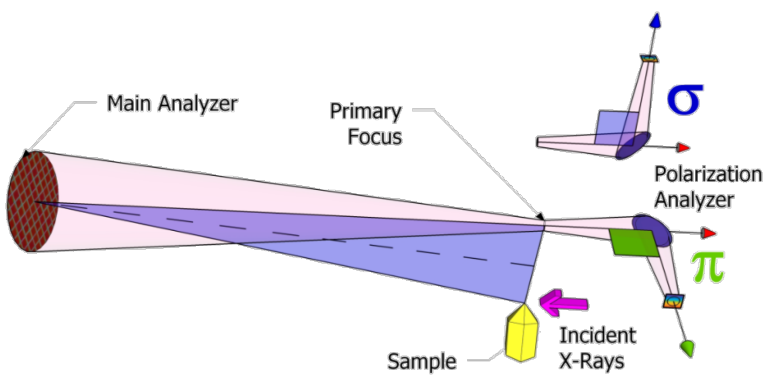
Arrays of dislocations in an epitaxial layer arising from glide and multiplication of dislocations in the substrate was previously reported in studies of etch pits and photoluminescence: X. Zhang et al., JAP 102, 093520 (2007)

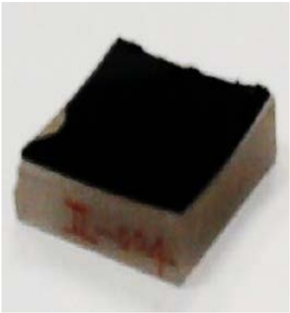
Polarization Analysis for Resonant Inelastic X-ray (RIXS) Scattering

Xuan Gao (WMU), Clem Burns (WMU), Diego Casa (APS), Naresh Kujala (APS), Al Macrander (APS)

Goal: Create an analyzer to measure polarization of the scattered x-ray in RIXS

- Make analyzer for iridates - Ir L3 edge.
- Analyzer is toroidally bent high quality Si (4 4 4).
- Polarization analysis provides symmetry information about electronic excitations.
- Allows studies of magnetic excitations.
- Reduces elastic background.

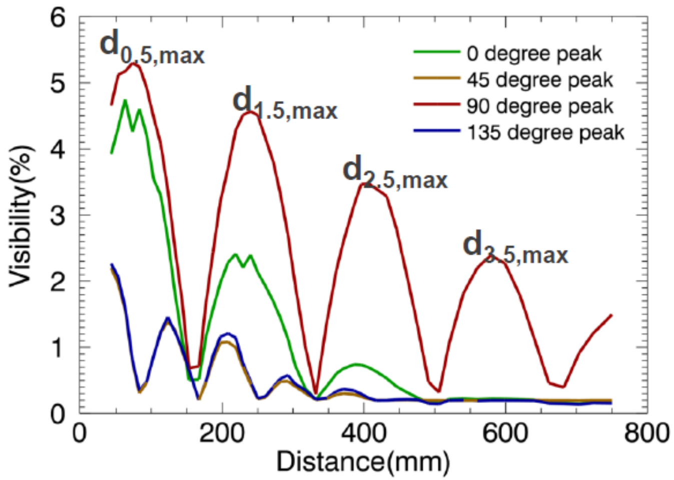




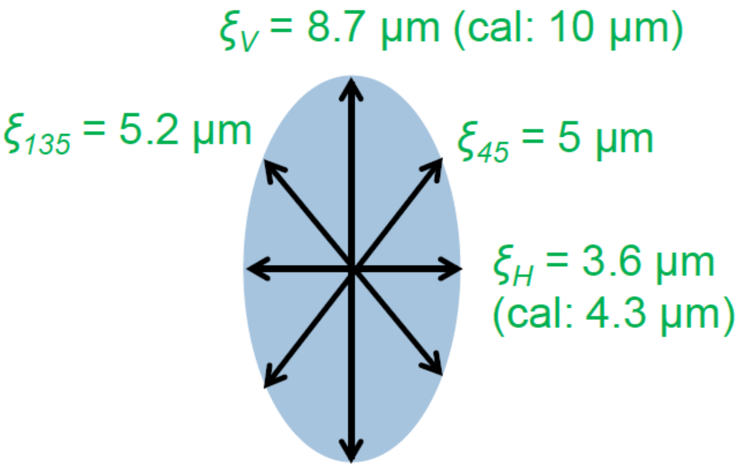
General Scheme – Scattered x-rays from sample are energy analyzed by the main analyzer and than polarization analyzed by the polarization analyzer to measure the two polarization components. Signal is then focused unto a strip detector.

Coherence length measurements with a 2-D grating at beamline 1-BM at the APS

- Measurement of the coherence of the Beam wavefront reflected from a Si(111) double crystal monochromator



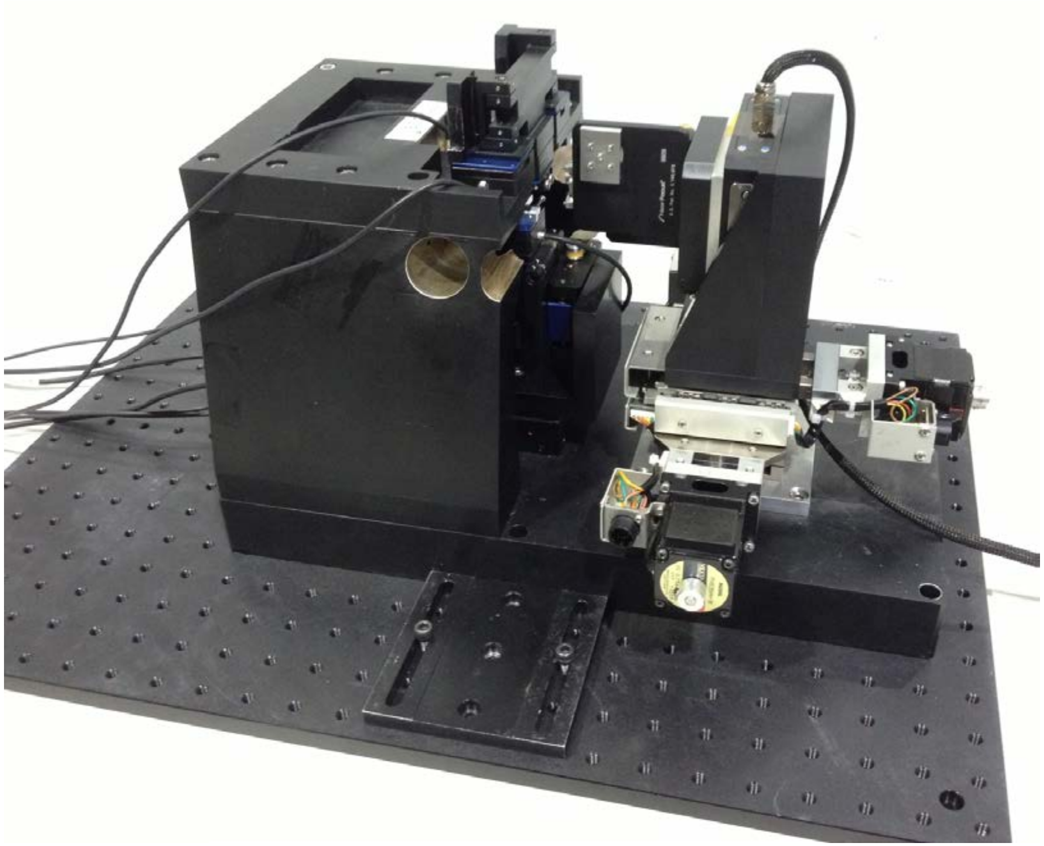
Measured Coherence length(ξ)				
Peak	0 ° (H)	90 ° (V)	45	135
ξ(μm)	3.6	8.7	5	5.2



Coherence area of the wavefront as seen from down stream at the grating position

Shashidhara Marathe, Talbot Interferometry Workshop, Gaithersburg, MD, June 17, 2013.

MLL Microscope: also suitable for testing FZPs

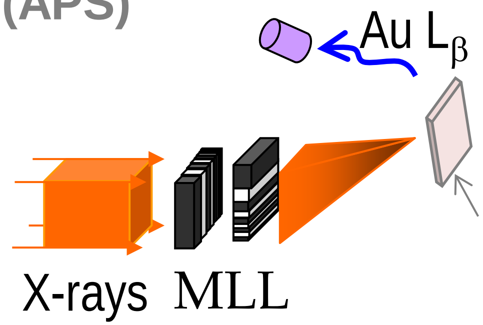


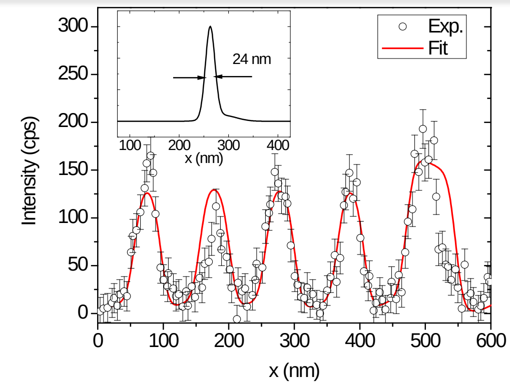
D. Shu, H. Yan, and J. Maser, U.S. patent 7,597,475 (2009)

Initial Studies: Fuel Cells, Catalysts

Multilayer Laue Lens Microscope (APS)

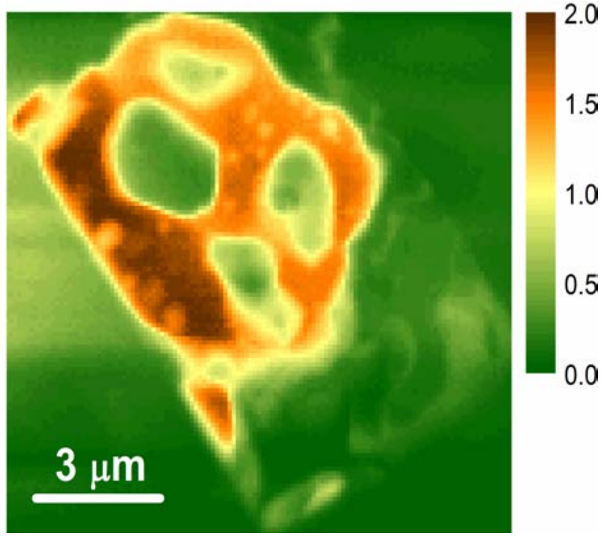
25 nm x 27 nm spot
2D Efficiency: 17% @ 19.5 keV





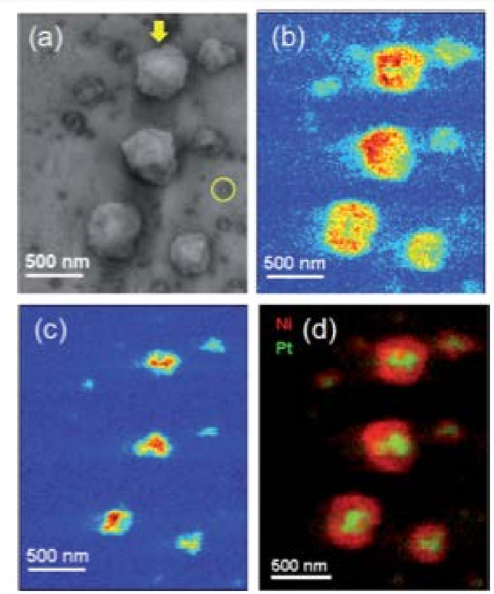
Collaborative work with NSLSII HXN team, Y.C. Kang, W. Chiu:

Solid Oxide Fuel Cells



H. Yan, Y. S. Chu, J. Maser, E. Nazaretski, J. Kim, H. C. Kang, J. J. Lombard, W. K. S. Chiu. Scientific Reports, 3, 1307, (2013)

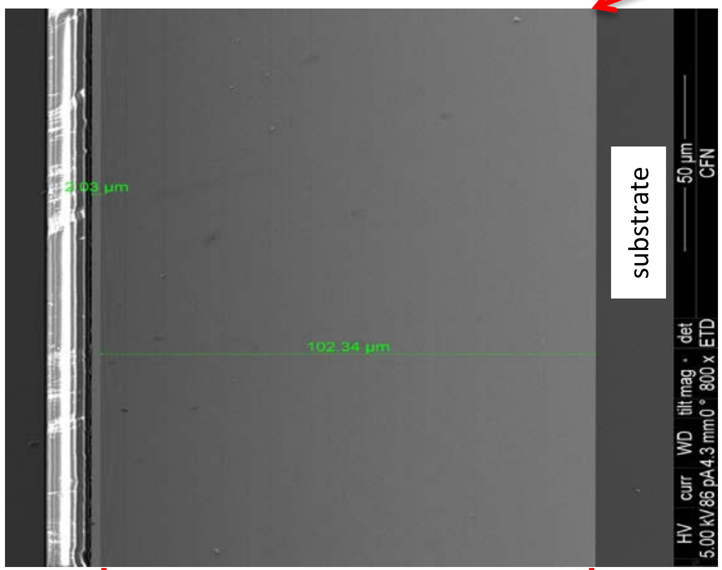
Core shell nanocatalyts



H.C. Kang, H. Yan, Y.S. Chu, S.Y. Lee, J. Kim, E. Nazaretski, C. Kim, O. Seo, D. Y. Noh, A. T. Macrander, G.B. Stephenson, J. Maser. Nanoscale, DOI: 10.1039/c3nr00396e, (2013)

MLL Efficiency Measurement, Nov. 2013

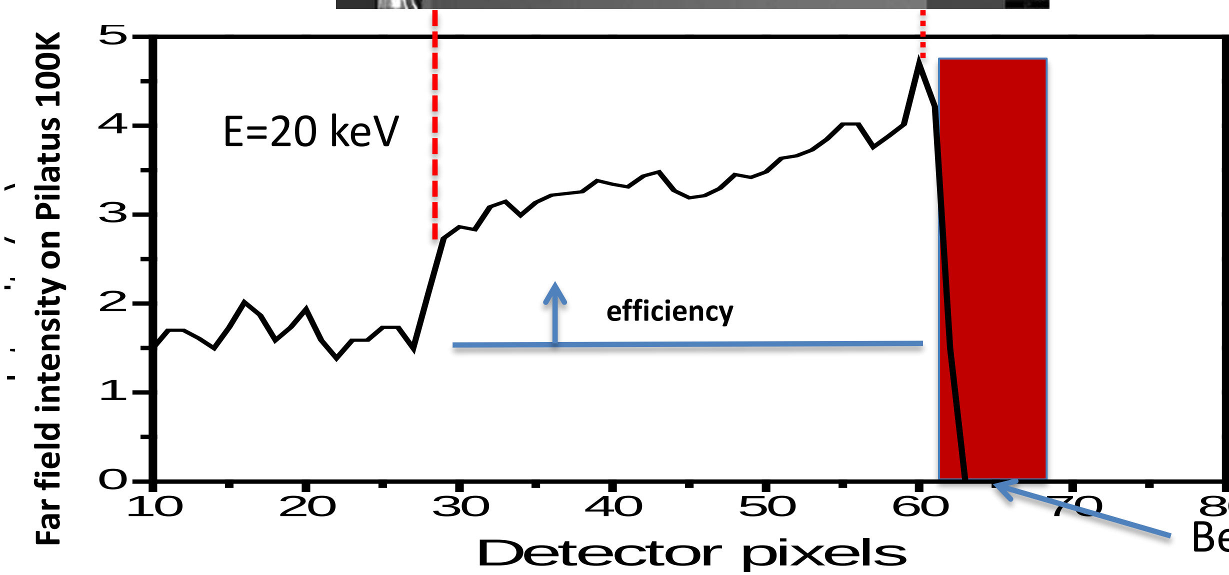
4 nm outermost zone



MLL from BNL:
Ray Conley, Nathalie Boutet

102 μm thick total growth/ 15,170 total layers (4 cathodes used)

Al-5%Si matrix / **WSi_2** Reactive sputtering with $10\%N_2$ /90% Ar

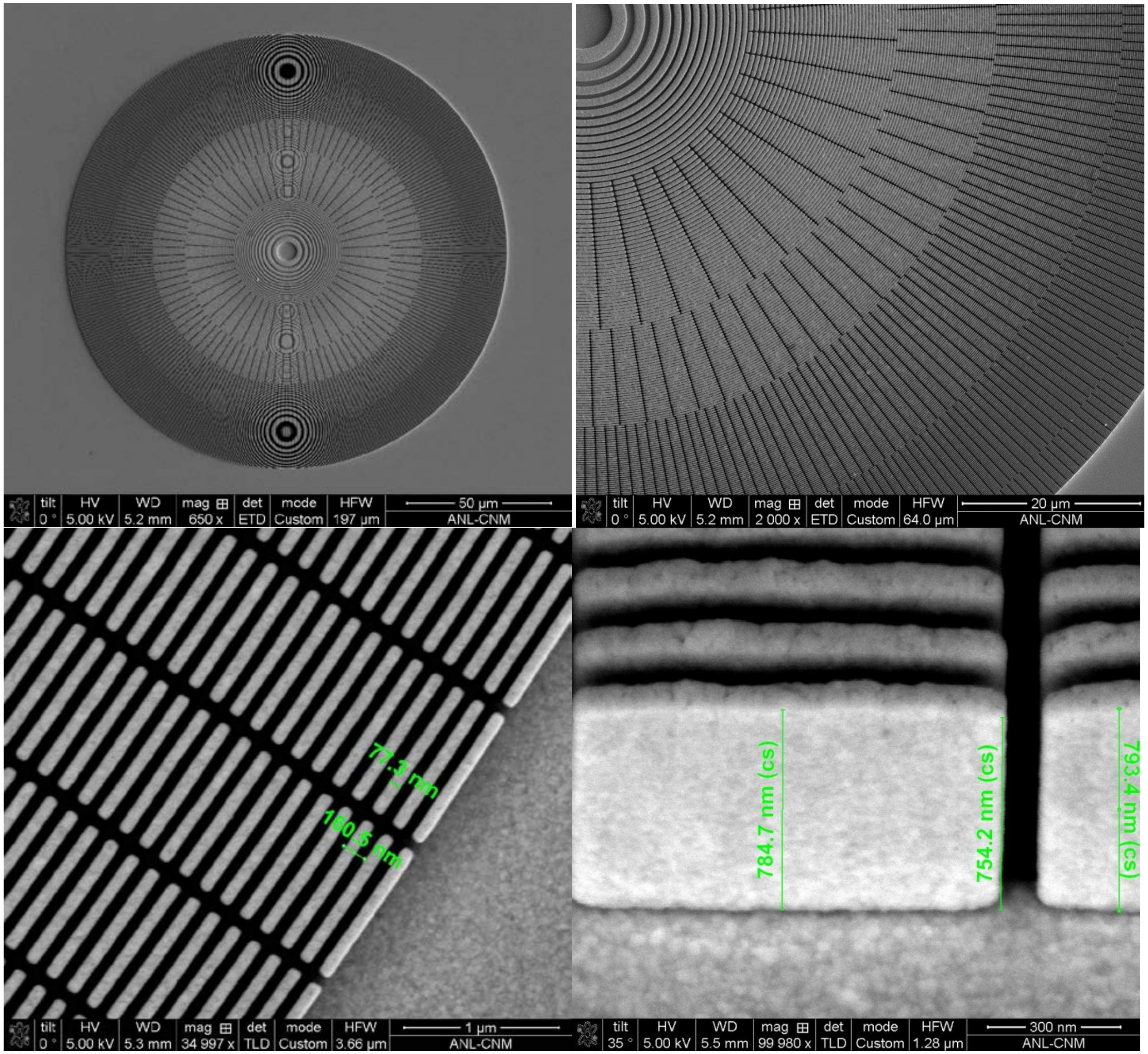


Data is the intensity on Pilatus 100K in the far field

Beamstop for direct beam

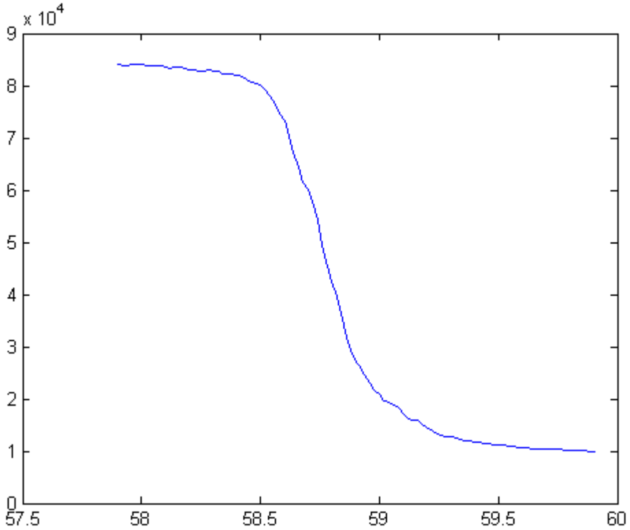
A. Macrander, H. Yan, J. Maser, N. Kujala, M. Wojcik, A. Kubec, K. Goetze, J. Kirchman

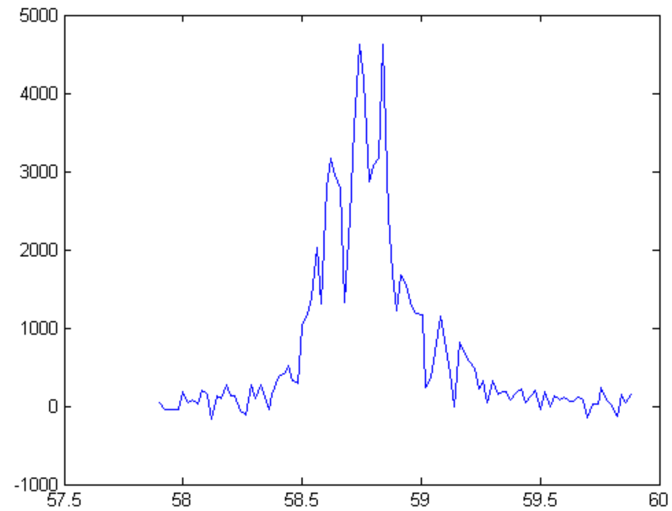
Michael Wojcik: Fresnel Zone Plate Study, Nov. 2013



3 zone plates fabricated for intermediate stacking. Slightly different focal lengths.
~150 um diameter
80 nm outer zone width
800 nm thick at outer zones

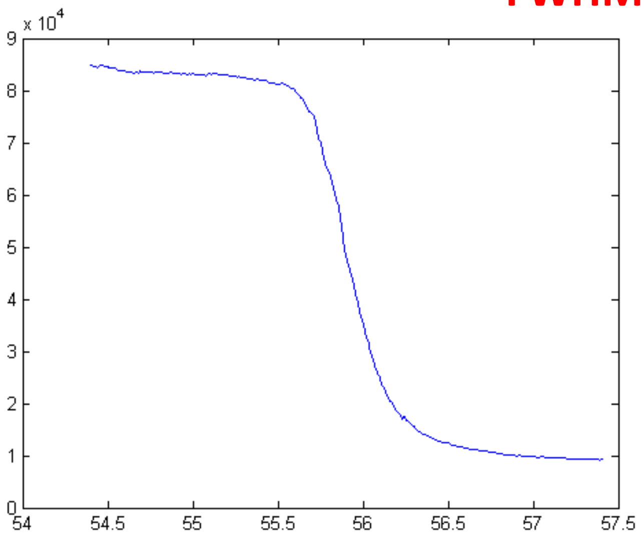
Pinhole Scans – 30 um pinhole, 8 keV : preliminary analyses

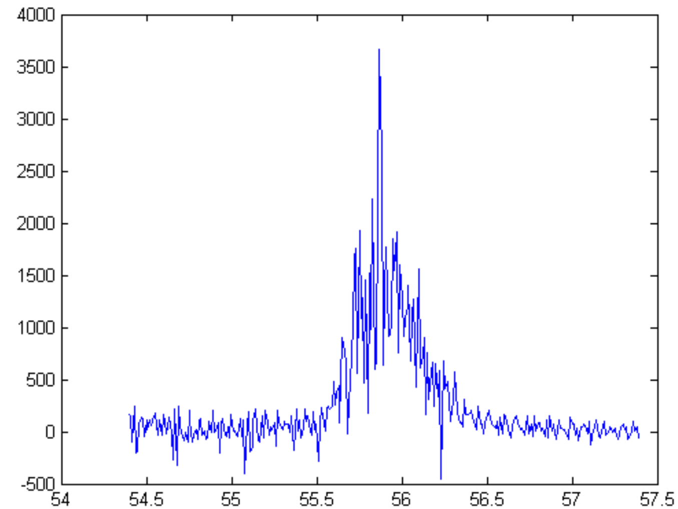




2 um scan
20 nm steps

FWHM : 280-350 nm, 14 % efficiency





3 um scan
10 nm steps

M. Wojcik and S. Marathe, Nov. 2013

Optics Testing Done To-date at 1-BM

- X-ray topography: monochromatic & white beam; exposures as short as 50 msec
- Talbot interferometry for coherence characterization
- Analyzers for IXS: polarization selection, spherical backscattering
- Focusing optics: K-B mirrors, FZPs, MLLs

Thank you for your attention