COSMIC:

A new facility for COherent Scattering and MICroscopy

H. A. Padmore

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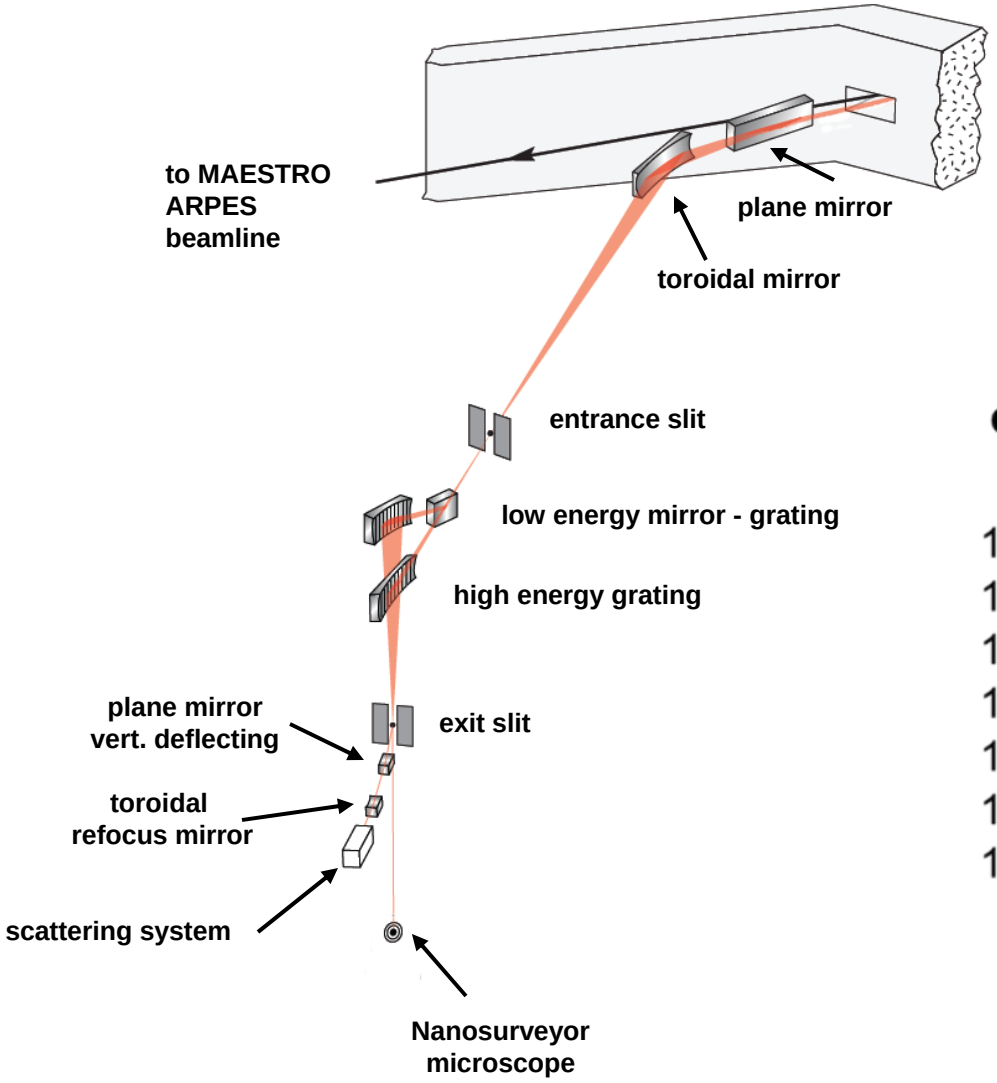
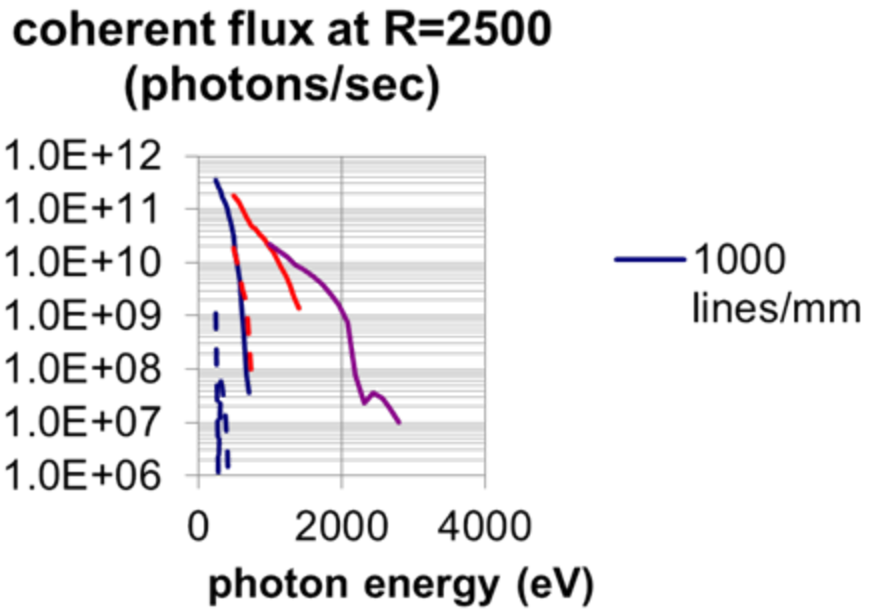
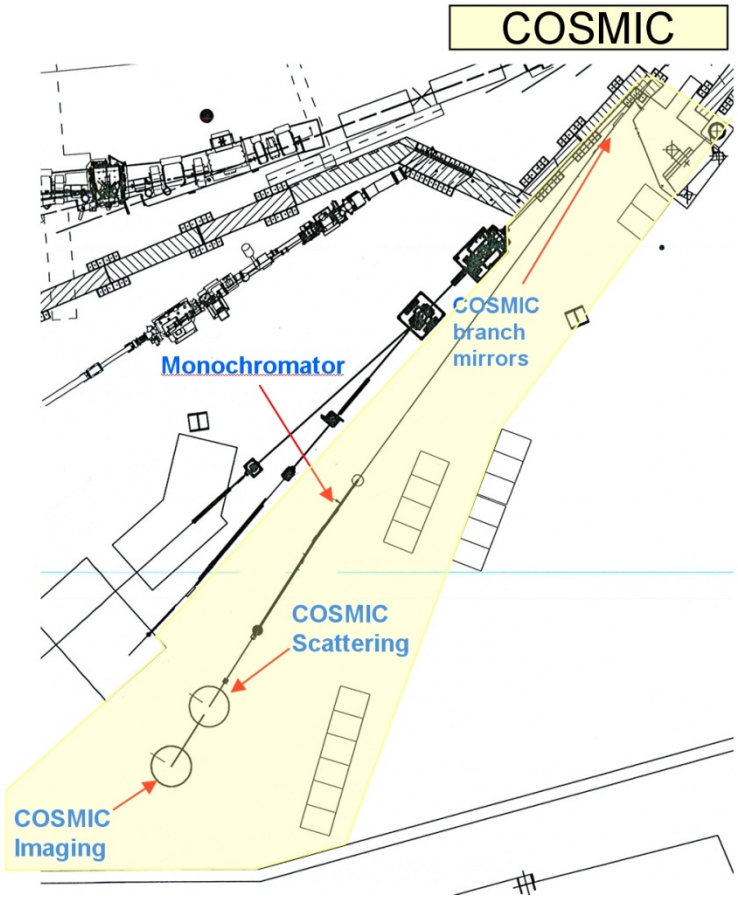
COSMIC Beamline: Sector 7 of ALS

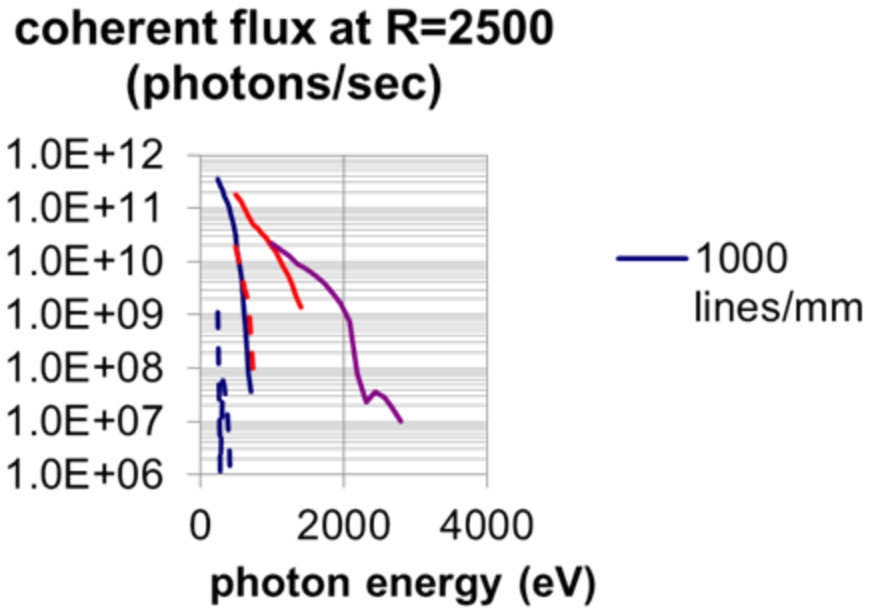


Elliptically Polarizing Undulator (EPU)
270 – 2000 eV : full polarization control



COSMIC Beamline: Sector 7 of ALS





COSMIC Workshop Goals:

- discuss the science that could be enabled with COSMIC

- nucleate a user community that will help develop and apply COSMIC

- define the experimental requirements of the two end stations

- validate the basic beamline parameters (energy range, polarization etc)

Soft x-ray techniques: increasing complexity

- absorption spectroscopy — chemical / magnetic state

- scanning transmission x-ray microscopy (STXM) — 10 nm resolution chemical mapping and spectroscopy

- resonant soft x-ray scattering RSoXS — chemically selective statistical distribution of electron density

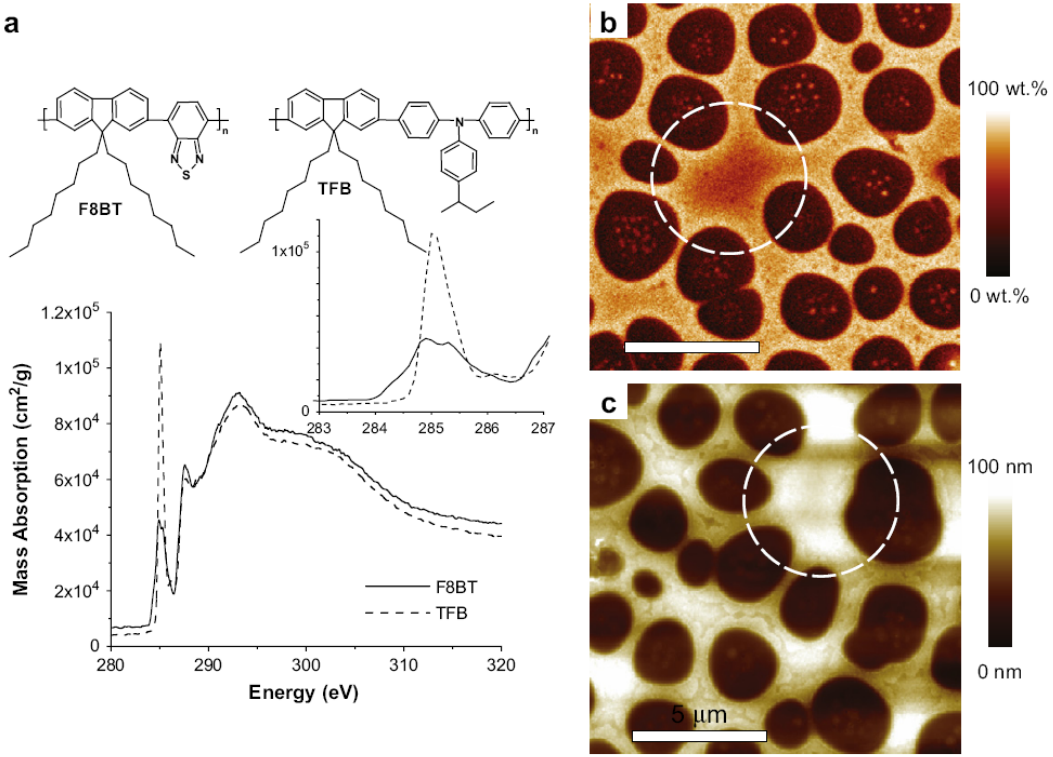
  - coherent RSoXS

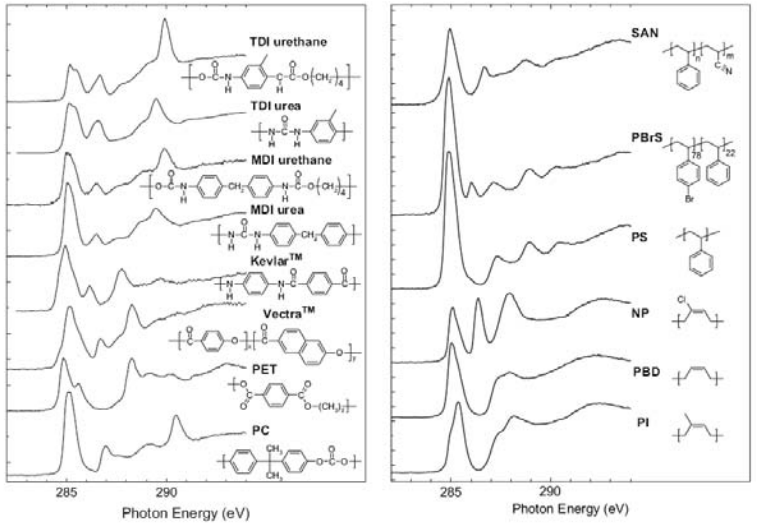
- Ptychography: a combination of STXM and RSoXS

  - resolution beyond lens based systems……extended resolution STXM
  - no depth of field limitations in 3d
  - large sample to focusing optics distance

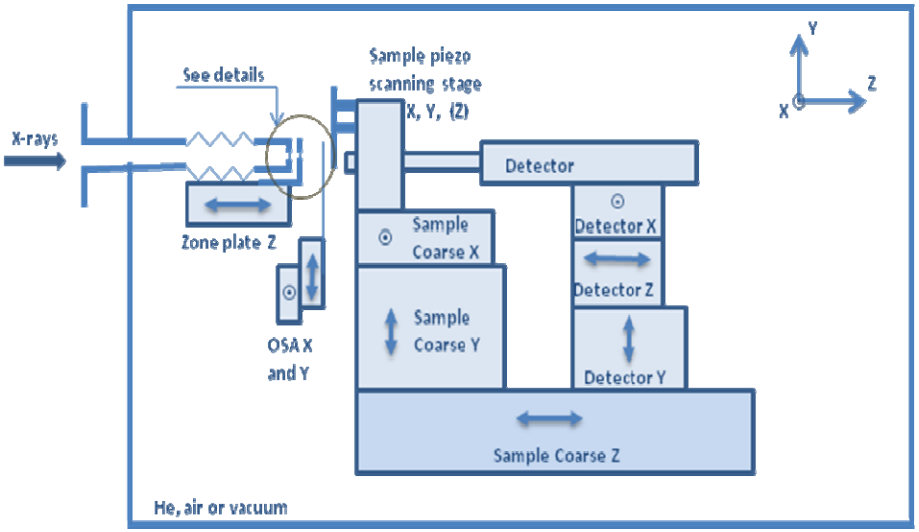
Soft X-ray Spectroscopy

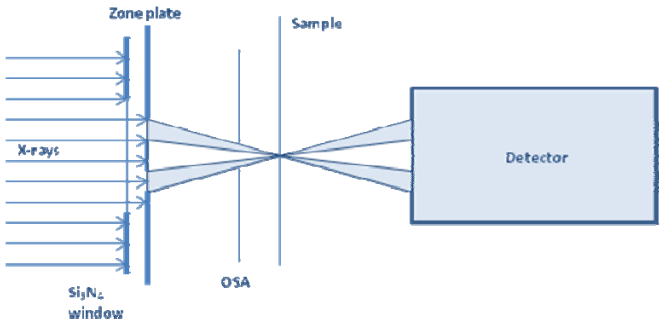
H. Ade, A.P. Hitchcock / Polymer 49 (2008) 643–675

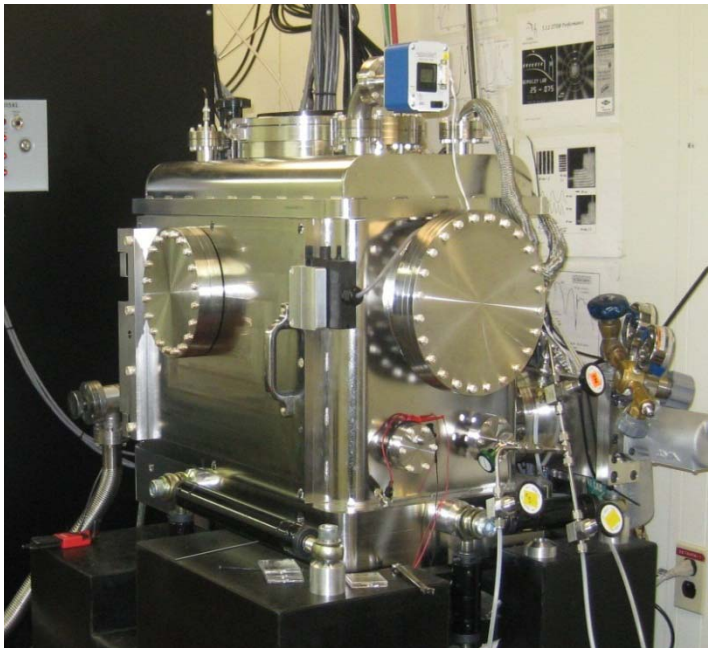




Conventional Scanning Transmission X-ray Microscopy (STXM)



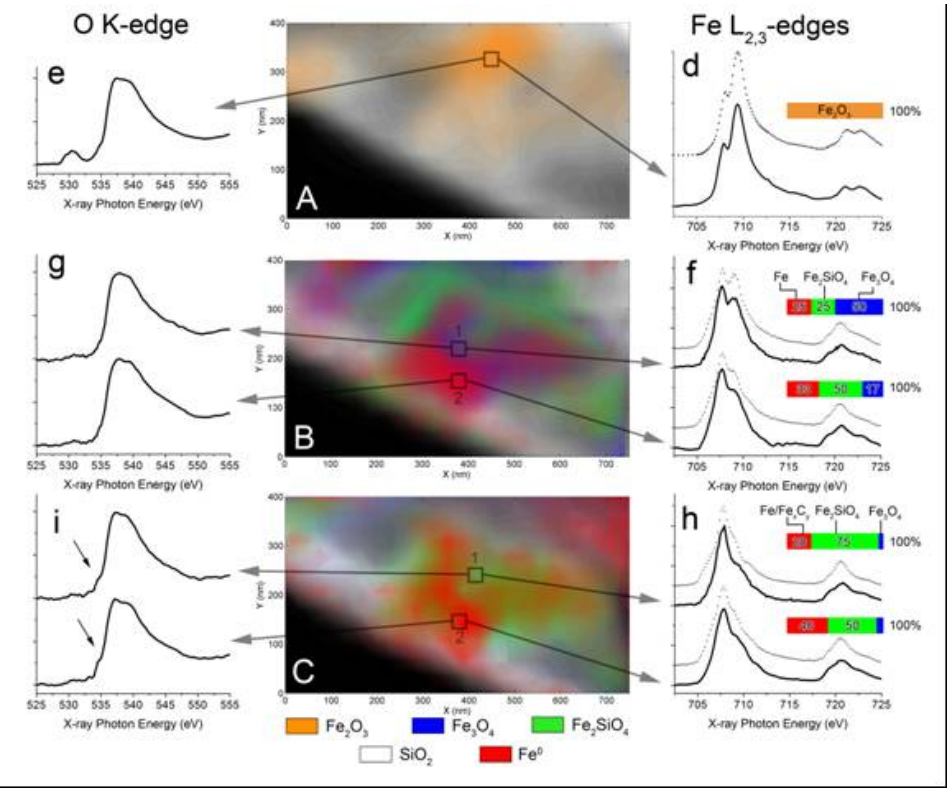


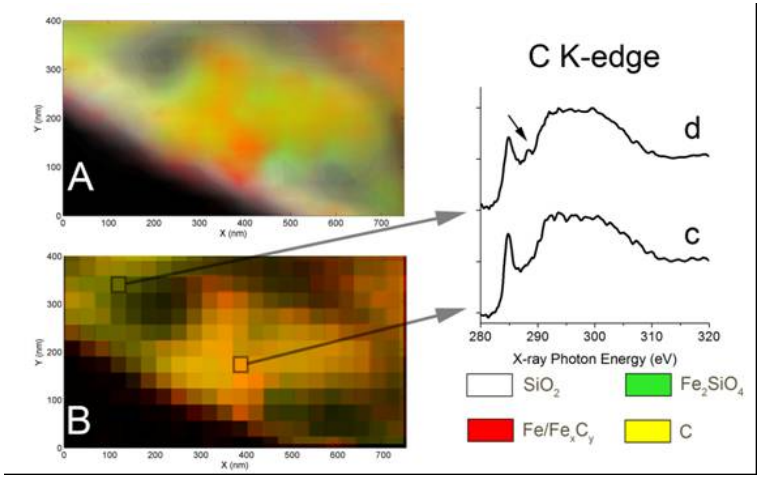


Tyliszczak, Kilcoyne et al. BL 11.0, 5.3.2

Conventional Scanning Transmission X-ray Microscopy (STXM)

complex iron oxide based Fischer-Tropsch catalyst





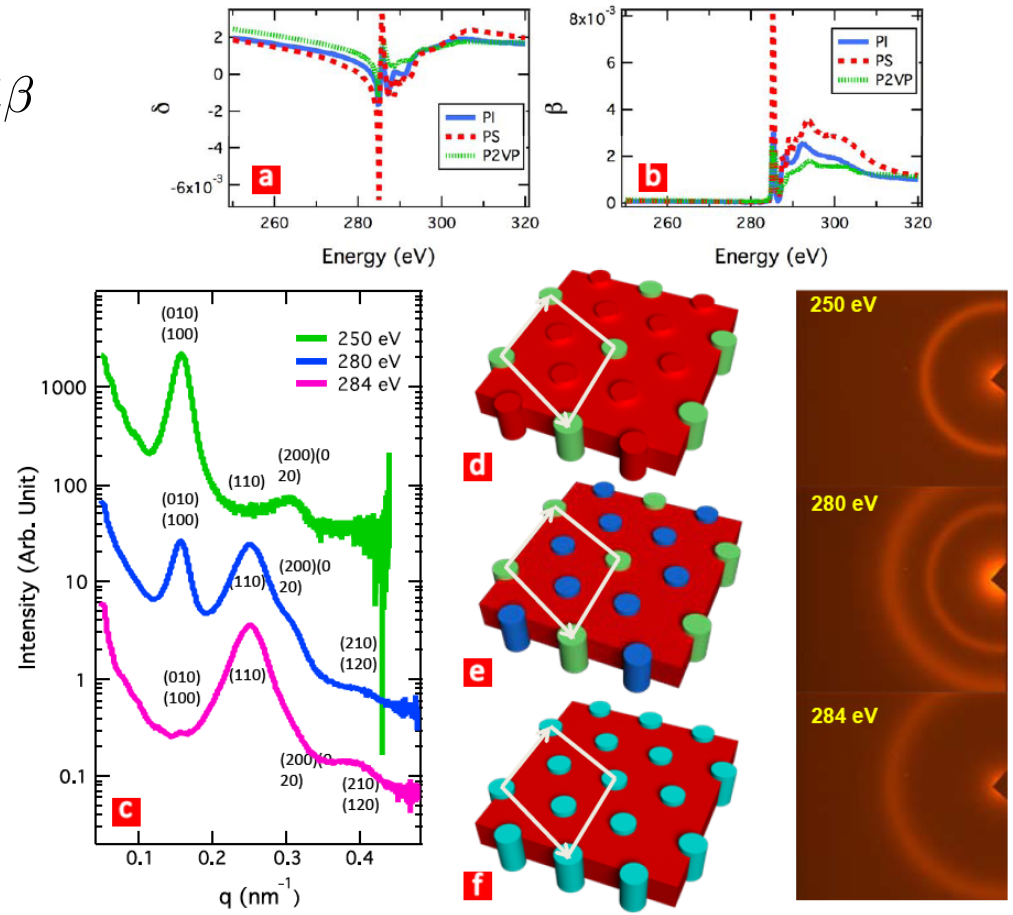
Chemical contour maps of a region of a catalyst particle during the different stages of reaction. A: Before treatment at RT in 1 bar He. B: After 2h in H2 at 350ºC. C: After 4h in CO/H2 at 250ºC. The corresponding regions of the O K-edge (e, g, i) and Fe L2,3-edge spectra (d, f, h) are indicated in the figures. Dotted lines indicate the linear combination fits, with the bars representing the contribution of the different phases to the spectra.

In situ studies, like this one of catalytic reactions, are using gas flow cells which are relatively bulky and the current high resolution zone plates can not be used because they have too short working distance. Diffraction enhanced imaging-spectroscopy using longer focal length zone plates may be the solution.

E. de Smit, I. Swart, J. Creemer, G. H. Hoveling, M. K. Gilles, T. Tyliszczak, P. J. Kooyman, H. W. Zandbergen, C. Morin, B. M. Weckhuysen and F. M. F. de Groot, Nature **456**, 222 (2008).

Resonant Soft X-ray Scattering: RSoXS

$$n = 1 - \delta + i\beta$$

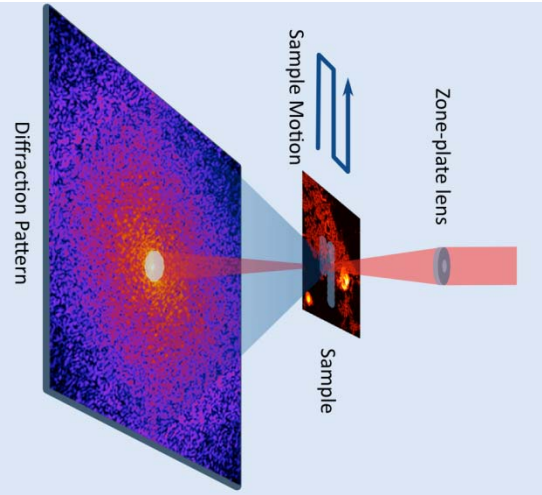


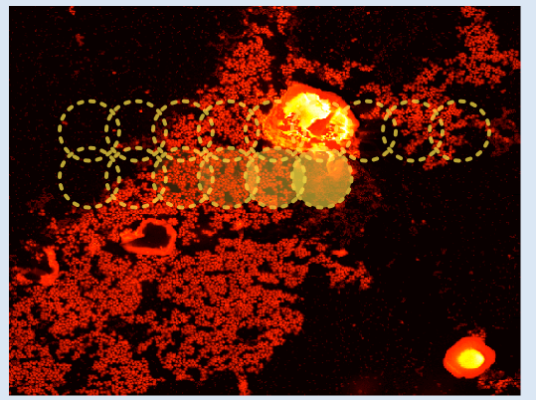
- tuning to a feature in the near edge region gives chemical selectivity

- scattering at a resonant energy allows measurement of the average spatial distribution of a chemical species

Cheng Wang, Dong Hyun Lee, Alexander Hexemer, Myung Im Kim, Wei Zhao, Hirokazu Hasegawa, Harald Ade, Thomas P. Russell, NanoLett (in press)

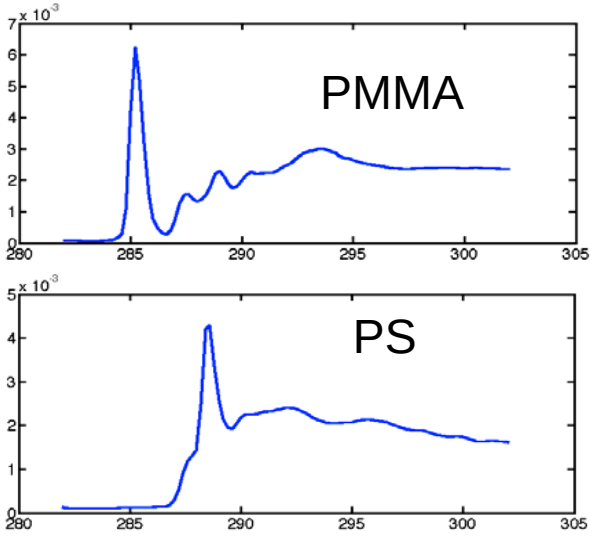
Combine STXM and Scattering: Ptychography



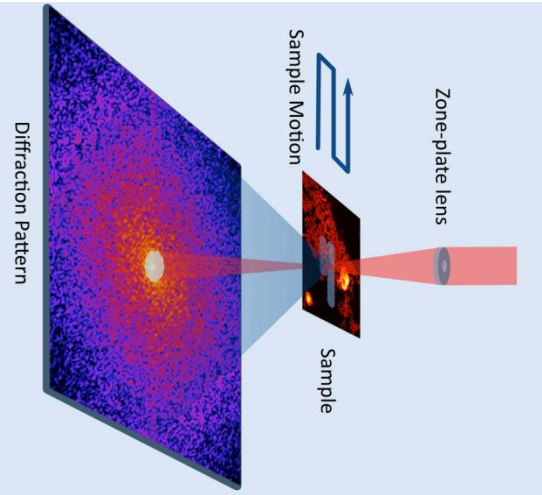


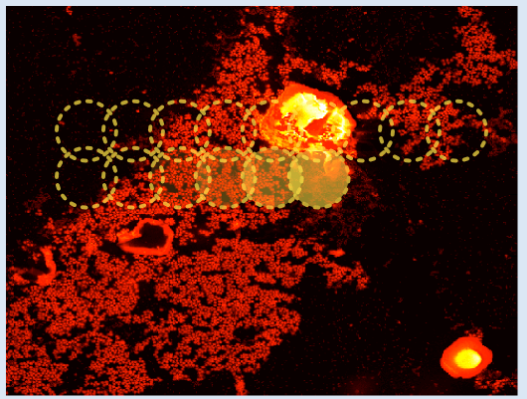
simulation of spectroscopic Ptychography using complex refractive index data assigned to pixel positions (Stefano Marchesini)

- large (300 nm) illumination spot from zone plate
- record diffraction pattern
- increment position by < spot size
- overlap allows direct phasing of the diffraction pattern
- resolution is wavelength limited
  - practical limits set by scattering power of sample, source brightness, damage
- real and imaginary parts of the refractive index can be recovered…..spectroscopy & phase contrast



Combine STXM and Diffraction: Ptychography





The Nanosurveyor

3 modes of operation:

- local area scattering (RSoXS with 300 nm probe size)

- *improved* resolution scanning transmission x-ray microscopy *i*-STXM

- large sample distance, phase contrast

- tomography (spectroscopic; phase contrast)

COSMIC Workshop Logistics:

- speakers: please stick to your times!

- talks: we would like to collect the talks: session chairs to collect

    - talks + posters will be put on the workshop website

- breakout sessions

    - scattering (conf room) / microscopy (auditorium)

    - short talks on science / techniques (please contact session organizers)

        - Oleg Shpyrko (Sujoy Roy) and David Shapiro (Stefano Marchesini)

    - discussion of end station specifications

- lunch

    - Building 62 (posters), Molecular Foundry patio (see map)

COSMIC Workshop Agenda:

Tuesday August 2 2011

Session Chair: Howard Padmore

Time	Name	Topic	Location
7:30-8:15a	**Coffee**		Auditorium Lobby
8:15-8:35a	Howard Padmore (LBNL)	Welcome / What is COSMIC?	Auditorium (Bldg 66)
8:35-9:15a	Steve Kevan (Univ of Oregon)	Spatiotemporal Correlations in Complex Magnetic Systems	Auditorium (Bldg 66)
9:15-9:55a	Andreas Menzel (Swiss Light Source)	Coherent diffractive tomography. A practitioner's view	Auditorium (Bldg 66)
9:55-10:15a	**Break**		Auditorium Lobby
10:15-10:40a	Dula Parkinson (LBNL)	X-ray Microtomography: Scientific application and the drive to higher resolution	Auditorium (Bldg 66)
10:40-11:05a	Ben Gilbert (LBNL)	X-ray Microscopy and Spectromicroscopy Needs for Environmental and Human Nanotoxicology	Auditorium (Bldg 66)
11:05-11:30a	Jordi Cabana (EETD/LBNL)	[Battery research and the opportunities for new x-ray techniques]	Auditorium (Bldg 66)
11:30-11:55a	Chris Jacobsen (Argonne Nat'l Lab)	Ptargets for Ptychography	Auditorium (Bldg 66)
12:00-1:30p	**Lunch**		Bldg 62 - Main Conf Room (62-203)
Session Chair: Sujoy Roy			
1:30-1:55p	Eric Fullerton (Univ of California San Diego)	X-ray imaging of structure and magnetism in thin films and nanowires	Auditorium (Bldg 66)
1:55-2:20p	Tom Russell (Univ of Massachusetts, Amherst)	Frontiers in Soft Matter: Can X-ray Scattering and Microscopy Help	Auditorium (Bldg 66)
2:20-2:45p	S.K. Sinha (Univ of California San Diego)	XPCS on Hard and Soft Condensed Matter	Auditorium (Bldg 66)
2:45-3:00p	**Break**		Auditorium Lobby
3:00-3:15p	**Group Photograph**		Front of Bldg 66
3:15-3:55p	Adam Hitchcock (McMaster University)	Need for chemically sensitive imaging with ultra-high resolution: current STXM capabilities and opportunities for resonant ptychography	Auditorium (Bldg 66)
3:55-4:20p	David Shapiro (NSLSII - BNL)	Development of soft x-ray diffraction imaging methods for materials science at NSLS-II	Auditorium (Bldg 66)
4:20-4:45p	Elizabeth Blackburn (Univ of Birmingham)	Slow Relaxations in Functional Magnetic Materials	Auditorium (Bldg 66)
4:45-5:10p	Brian Collins (North Carolina State Univ)	Organic Devices: An Application in Need of New Tools	Auditorium (Bldg 66)

COSMIC Workshop Agenda:

Wednesday August 3 2011			
Session Chair: Stefano Marchesini			
7:30-8:30a	**Coffee**		Auditorium Lobby
8:30-9:05a	Jim DeYoreo (LBNL Molecular Foundry)	Challenges and opportunities in nanoscale imaging at the Molecular Foundry	Auditorium (Bldg 66)
9:05-9:30a	Matthew Marshall (PNNL)	Towards High Resolution Chemical Imaging to Characterize the Structure and Biogeochemical Function of Biofilms	Auditorium (Bldg 66)
9:30-9:55a	Kerstin Kleese van Dam (PNNL)	Challenges of data intensive imaging analysis at experimental facilities	Auditorium (Bldg 66)
9:55-10:10a	**Break**		Auditorium Lobby
10:10-10:35a	Oleg Shpyrko (Univ of California San Diego)	TBA	Auditorium (Bldg 66)
10:35-11:00a	Oliver Gessner (LBNL Chemical Sciences)	Chemical Sciences Needs for Ultrahigh Resolution X-ray Microscopy	Auditorium (Bldg 66)
11:00-11:25a	Stuart Wilkins (Brookhaven Nat'l Lab)	TBA	Auditorium (Bldg 66)
11:25-11:50a	Paulo Monteiro (Univ of California Berkeley)	Green Cement: Microscopy under 10nm Resolution	Auditorium (Bldg 66)
11:50-12:25p	Rui Xu / Jose Rodriguez (UCLA)	3D Coherent Diffractive Imaging of Materials and Whole Cells	Auditorium (Bldg 66)
12:25-12:30p	Breakout Session Briefing		Auditorium (Bldg 66)
12:30-1:30p	**Lunch**		Bldg 62 - Main Conf Room (62-203)
Session Chair (Imaging): Dave Shapiro			
Session Chair (Scattering): Oleg Shpyrko			
1:30-3:00p	BREAKOUT SESSION - IMAGING		Auditorium (Bldg 66)
1:30-3:00p	BREAKOUT SESSION - SCATTERING		Auditorium Conf Room
3:00-3:30p	Panel Discussion and Closing Remarks		Auditorium (Bldg 66)