Cross-Cut Review of Interface and Liquid Surface Scattering Science

Paul Zschack
X-ray Science Division

APS/Users Monthly Operations Meeting - October 27, 2010

Charge to the Review Committee

- Assess the quality of science in these areas (hard surfaces and interfaces, liquid surface scattering, soft interfaces, etc.) at the APS.
- Provide advice on the optimum level of support (beamlines, instrumentation, time available, staffing).
- Assess the APS upgrade plans as related to these areas of science to determine if they are appropriate, i.e. sufficient. Comment on current priorities or, if needed, prioritize options.

Review Panel Membership

Friso van der Veen, SAC, Chair	*Paul Scherrer Institut*
Pulak Dutta	*Northwestern University*
Jeff Kortright	*Lawrence Berkeley National Laboratory*
Ka Yee Lee, SAC	*The University of Chicago*
Dan Neumann, SAC	*National Institute of Standards and Technology*
Chris Palmstrom	*University of California, Santa Barbara*
Eliot Specht	*Oak Ridge National Laboratory*
William Stirling	*European Synchrotron Radiation Facility*
Tom Irving APS Partner User Council, *ex-officio*	*Illinois Institute of Technology*
David Tiede APS Users Organization, *ex-officio*	*Argonne National Laboratory*

Agenda

October 6-7, 2010
Bldg. 402 Auditorium and Gallery

- Overview of Interface Science Capabilities: Current and Proposed
  Paul Zschack, X-ray Science Division, APS
- Quantum and Atomistic Effects in Thin Film Growth
  Tai-chang Chiang, University of Illinois at Urbana-Champaign
- Synthesis and Processing of Energy Related Materials and Structures
  Paul Fuoss, Materials Science Division, ANL
- Imaging Structure and Reactivity at the Liquid-Solid Interface
  Paul Fenter, Chemical Sciences and Engineering Division, ANL
- Why add in-situ Oxide MBE to the APS?
  Darrell G Schlom, Cornell University

Agenda

- Overview of Liquid Surface Scattering Science at the APS/Review of 8/2/10 LSS Workshop at the APS
  Mark Schlossman, University of Illinois at Chicago
- LSS: From Biomolecular Materials to Structural Biology
  J. Kent Blasie, University of Pennsylvania
- X-ray Studies of Liquid Surfaces: From Liquid Metals to Langmuir Monolayers
  Oleg Shpyrko, University of California at San Diego
- **Poster Session (over 90 Contributed posters)**

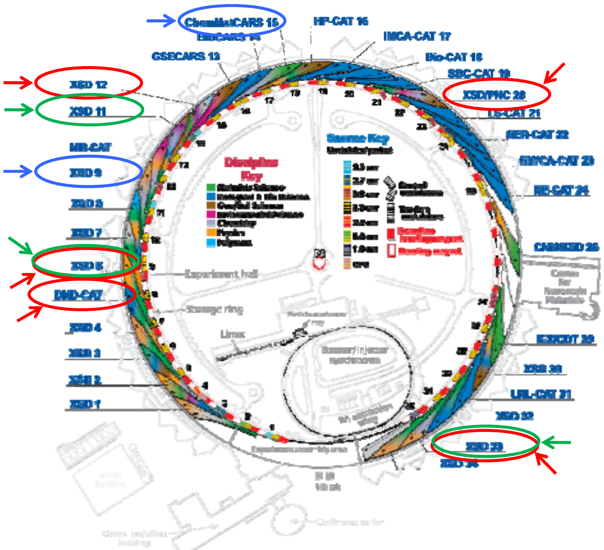
Beamlines for Interface Science at APS - Today

Presently, interface science activities are distributed to several APS sectors

Liquid Surface Scattering
9-ID, 15-ID

Ex-situ Interface Studies
6-ID, 11-ID, 33-ID, 33-BM

Growth Chambers (*in-situ studies*)5-ID, 6-ID, 12-ID, 20-ID, 33-ID



Interface Science at APS - Related Facilities

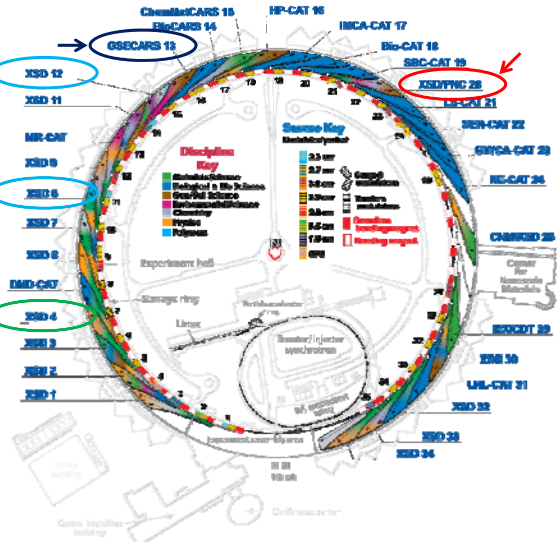
Additional interface science activities distributed at several APS sectors

Grazing Incidence Small-Angle X-ray Scattering 8ID, 12ID

Interfacial Magnetism 4ID

Surface/Interface Diffraction 13ID

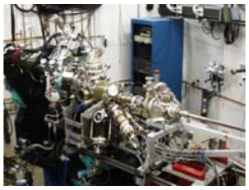
Surface Spectroscopy 20ID



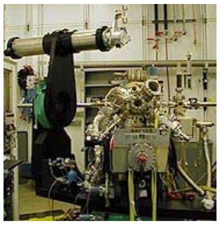
Surface & Interface Science Activities at APS Today

- Interfacial Magnetism (4-ID)
- XSW (5-ID, 33BM, 33-ID)
- Surface Diffraction (5-ID, 6-ID, 11-ID, 12-ID, 13-ID, 33-ID)
- Reflectivity (5-ID, 8-ID, 12-BM, 33-BM)
- Liquid Surface Scattering (9-ID, 15-ID)
- GISAXS (8-ID, 12-ID)
- MOCVD (12-ID), PLD (33-ID)
- Surface XAFS (20-ID)

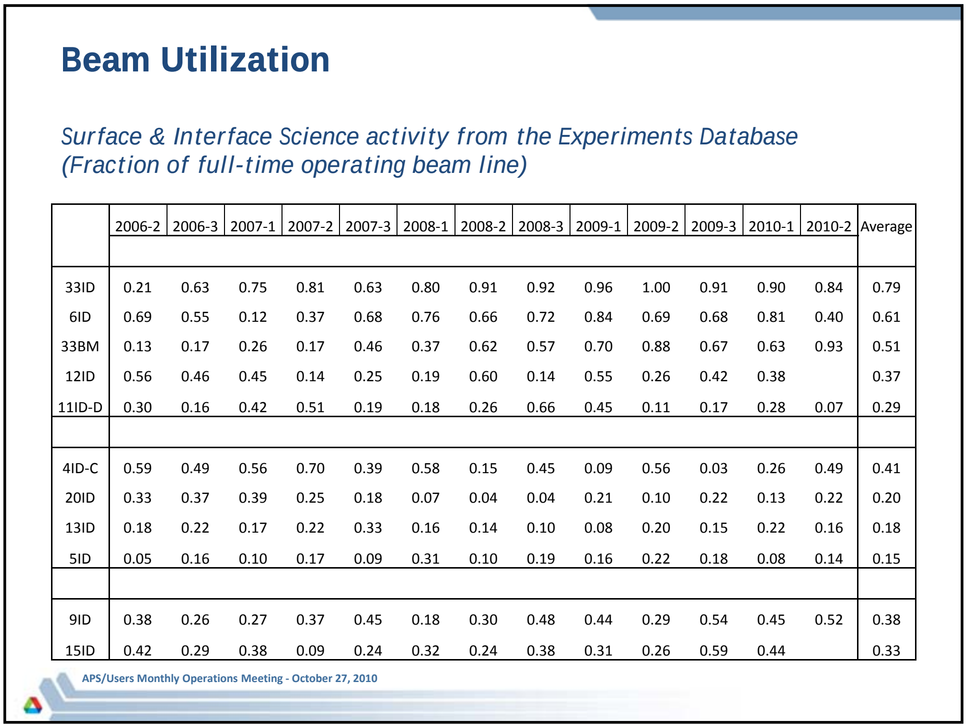
- Large, dispersed user community
- Many facilities under-utilized
  - (timeshare with other techniques)
- Conflicts with upgrade plans in some areas



6 ID-C UHV surface scattering chamber



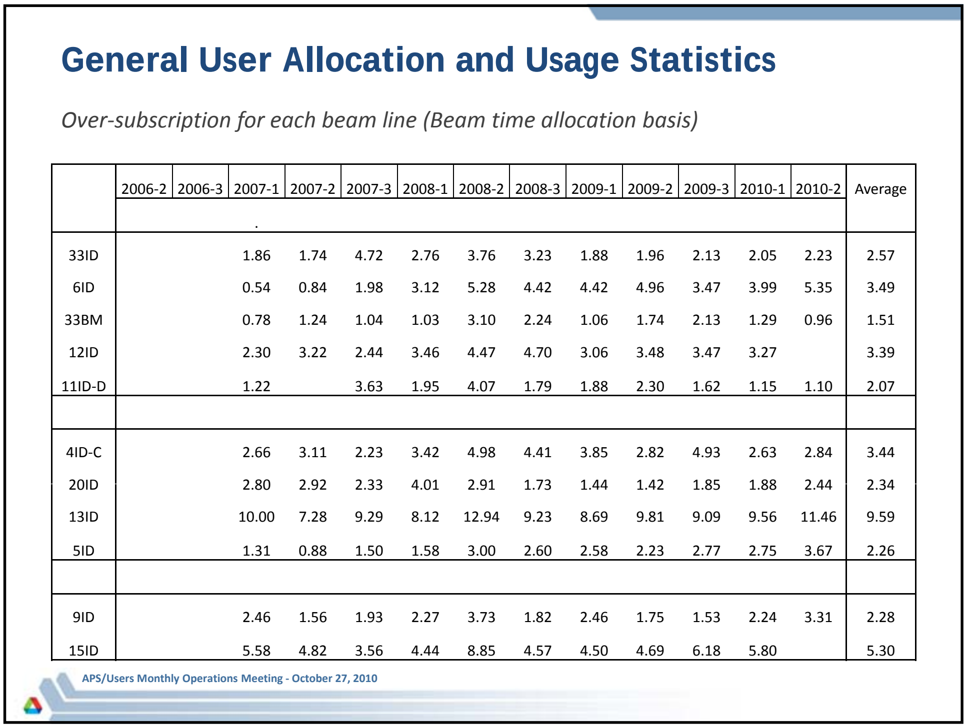
5 ID-C surface science chamber and diffractometer



Beam Utilization

Surface & Interface Science activity from the Experiments Database (Fraction of full-time operating beam line)

	2006-2	2006-3	2007-1	2007-2	2007-3	2008-1	2008-2	2008-3	2009-1	2009-2	2009-3	2010-1	2010-2	Average
33ID	0.21	0.63	0.75	0.81	0.63	0.80	0.91	0.92	0.96	1.00	0.91	0.90	0.84	0.79
6ID	0.69	0.55	0.12	0.37	0.68	0.76	0.66	0.72	0.84	0.69	0.68	0.81	0.40	0.61
33BM	0.13	0.17	0.26	0.17	0.46	0.37	0.62	0.57	0.70	0.88	0.67	0.63	0.93	0.51
12ID	0.56	0.46	0.45	0.14	0.25	0.19	0.60	0.14	0.55	0.26	0.42	0.38		0.37
11ID-D	0.30	0.16	0.42	0.51	0.19	0.18	0.26	0.66	0.45	0.11	0.17	0.28	0.07	0.29
4ID-C	0.59	0.49	0.56	0.70	0.39	0.58	0.15	0.45	0.09	0.56	0.03	0.26	0.49	0.41
20ID	0.33	0.37	0.39	0.25	0.18	0.07	0.04	0.04	0.21	0.10	0.22	0.13	0.22	0.20
13ID	0.18	0.22	0.17	0.22	0.33	0.16	0.14	0.10	0.08	0.20	0.15	0.22	0.16	0.18
5ID	0.05	0.16	0.10	0.17	0.09	0.31	0.10	0.19	0.16	0.22	0.18	0.08	0.14	0.15
9ID	0.38	0.26	0.27	0.37	0.45	0.18	0.30	0.48	0.44	0.29	0.54	0.45	0.52	0.38
15ID	0.42	0.29	0.38	0.09	0.24	0.32	0.24	0.38	0.31	0.26	0.59	0.44		0.33



General User Allocation and Usage Statistics

Over-subscription for each beam line (Beam time allocation basis)

	2006-2	2006-3	2007-1	2007-2	2007-3	2008-1	2008-2	2008-3	2009-1	2009-2	2009-3	2010-1	2010-2	Average
33ID			1.86	1.74	4.72	2.76	3.76	3.23	1.88	1.96	2.13	2.05	2.23	2.57
6ID			0.54	0.84	1.98	3.12	5.28	4.42	4.42	4.96	3.47	3.99	5.35	3.49
33BM			0.78	1.24	1.04	1.03	3.10	2.24	1.06	1.74	2.13	1.29	0.96	1.51
12ID			2.30	3.22	2.44	3.46	4.47	4.70	3.06	3.48	3.47	3.27		3.39
11ID-D			1.22		3.63	1.95	4.07	1.79	1.88	2.30	1.62	1.15	1.10	2.07
4ID-C			2.66	3.11	2.23	3.42	4.98	4.41	3.85	2.82	4.93	2.63	2.84	3.44
20ID			2.80	2.92	2.33	4.01	2.91	1.73	1.44	1.42	1.85	1.88	2.44	2.34
13ID			10.00	7.28	9.29	8.12	12.94	9.23	8.69	9.81	9.09	9.56	11.46	9.59
5ID			1.31	0.88	1.50	1.58	3.00	2.60	2.58	2.23	2.77	2.75	3.67	2.26
9ID			2.46	1.56	1.93	2.27	3.73	1.82	2.46	1.75	1.53	2.24	3.31	2.28
15ID			5.58	4.82	3.56	4.44	8.85	4.57	4.50	4.69	6.18	5.80		5.30

Quantum & Atomistic Effects in Thin Film Growth

Tai C. Chiang
Department of Physics, University of Illinois at Urbana-Champaign

Motivation: basic scientific principles relevant to materials fabrication and applications at the nanoscale

Unique feature of program: parallel studies of electronic structure using photoemission (SRC) to establish *correlation between physical & electronic structures* (atoms are bonded together by electrons)

- Quantum confinement effects, magic or preferred thicknesses
- Substrate effects: confinement gaps and surface/interface energies
- Roughness & nanostructure development
- Modulation and relaxation effects: substrate atomic steps, wires, …

Latest: metal-graphene/SiC interfaces, topological/Rashba films, …

Opportunities, challenges, & suggestions

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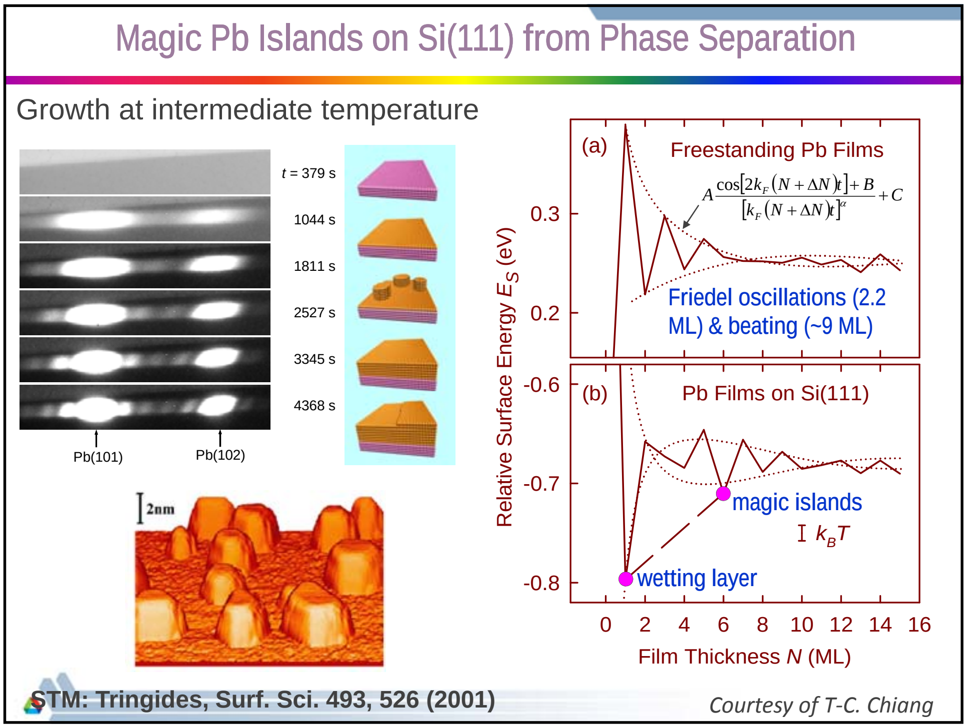
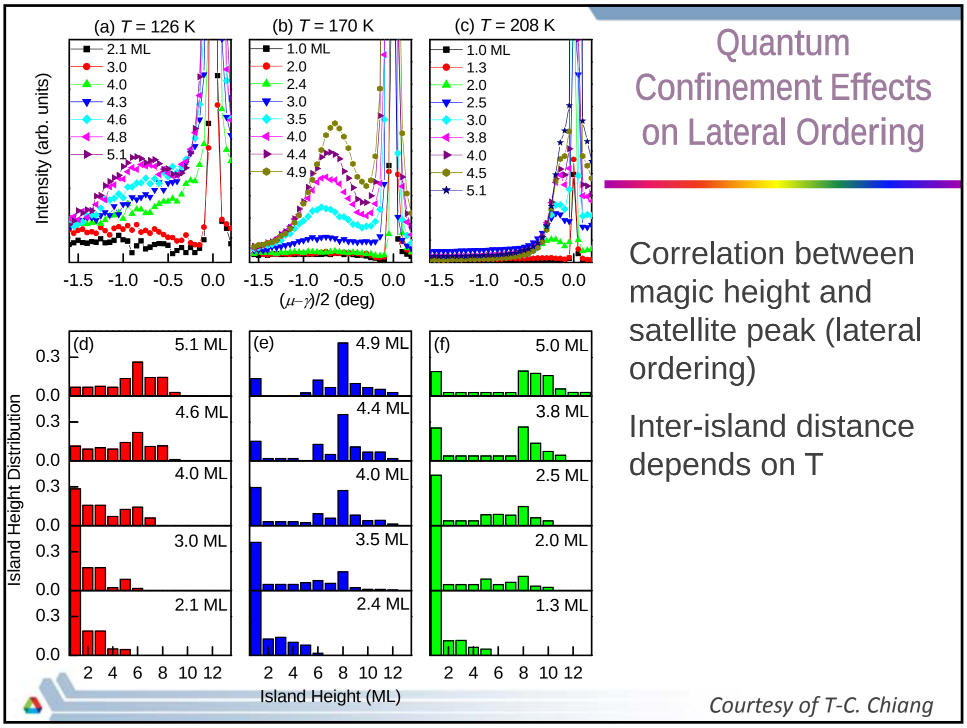


Magic Pb Islands on Si(111) from Phase Separation

Growth at intermediate temperature

STM: Tringides, Surf. Sci. 493, 526 (2001)

Courtesy of T-C. Chiang

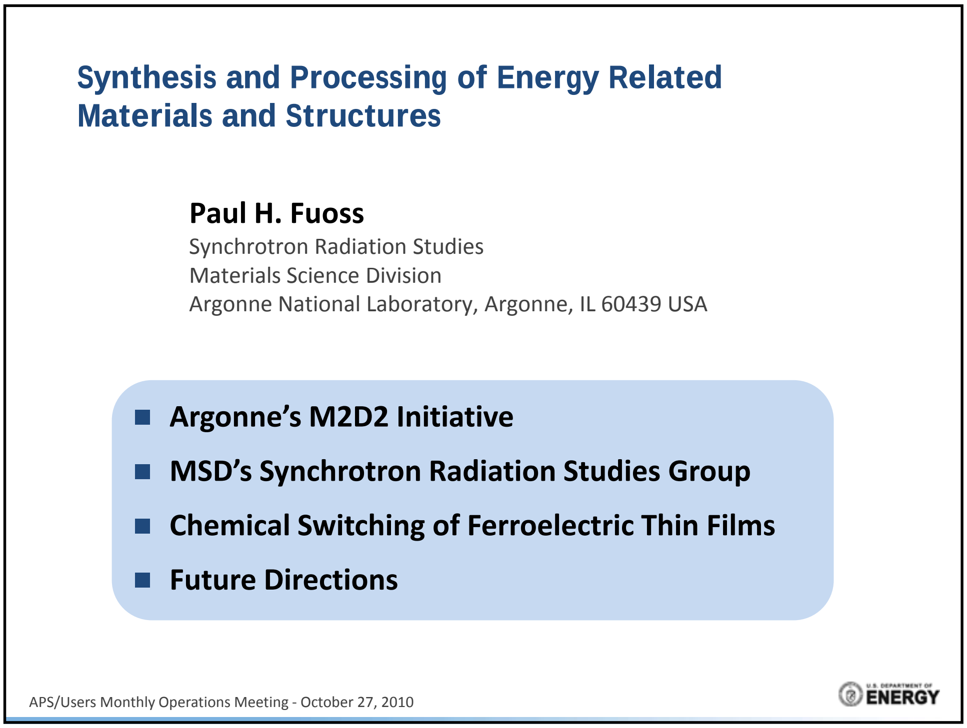


Quantum Confinement Effects on Lateral Ordering

Correlation between magic height and satellite peak (lateral ordering)

Inter-island distance depends on T

Courtesy of T-C. Chiang



Synthesis and Processing of Energy Related Materials and Structures

Paul H. Fuoss
Synchrotron Radiation Studies
Materials Science Division
Argonne National Laboratory, Argonne, IL 60439 USA

- **Argonne's M2D2 Initiative**
- **MSD's Synchrotron Radiation Studies Group**
- **Chemical Switching of Ferroelectric Thin Films**
- **Future Directions**

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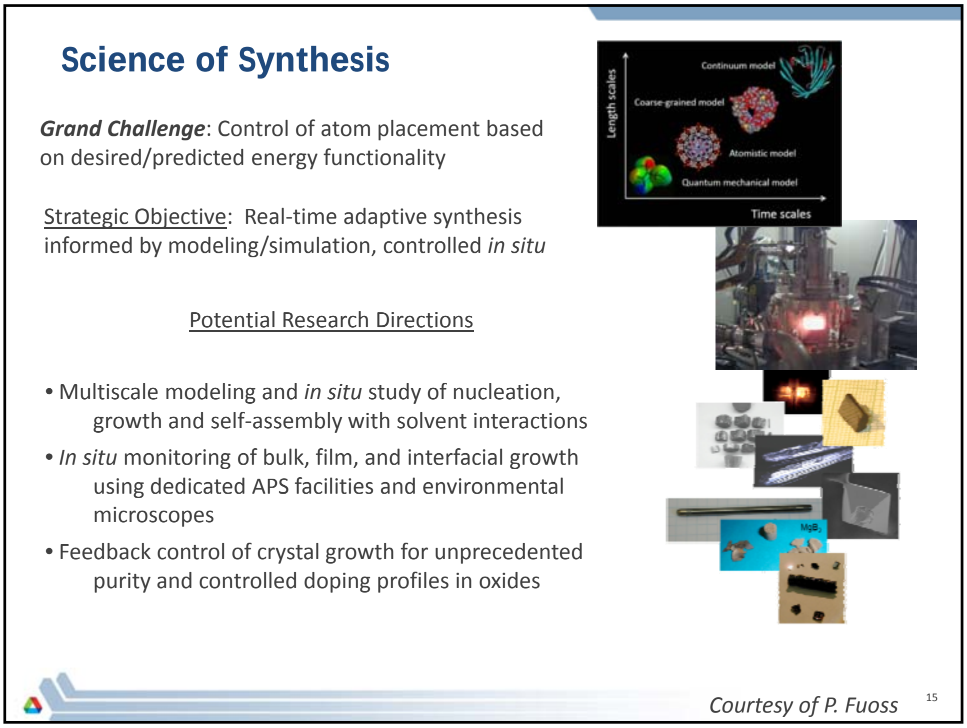


Science of Synthesis

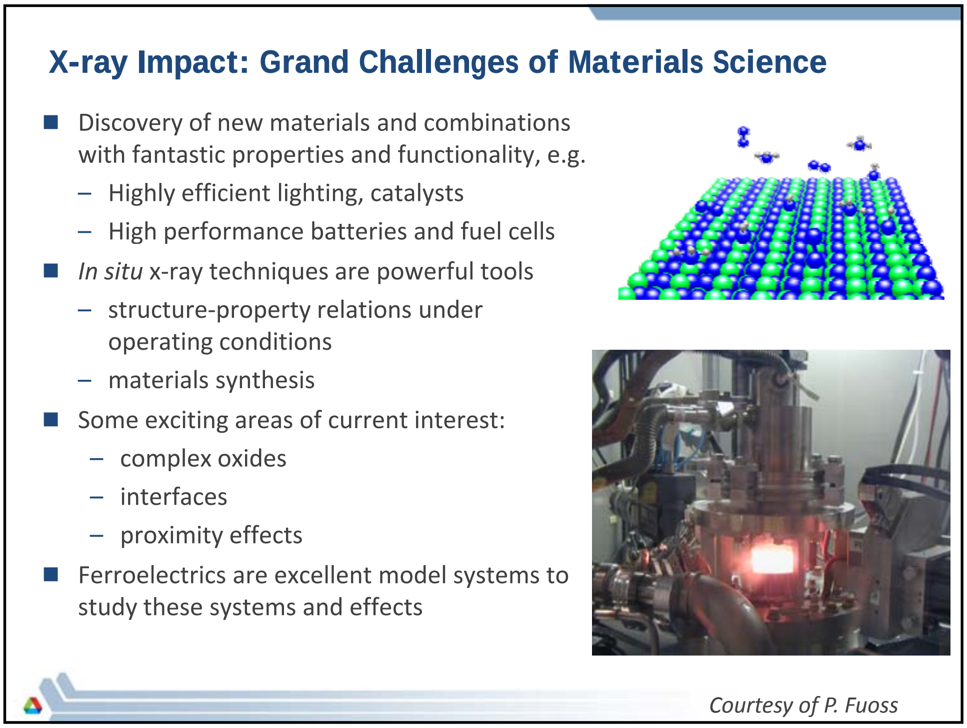
Grand Challenge: Control of atom placement based on desired/predicted energy functionality

Strategic Objective: Real-time adaptive synthesis informed by modeling/simulation, controlled *in situ*

Potential Research Directions

- Multiscale modeling and *in situ* study of nucleation, growth and self-assembly with solvent interactions
- *In situ* monitoring of bulk, film, and interfacial growth using dedicated APS facilities and environmental microscopes
- Feedback control of crystal growth for unprecedented purity and controlled doping profiles in oxides

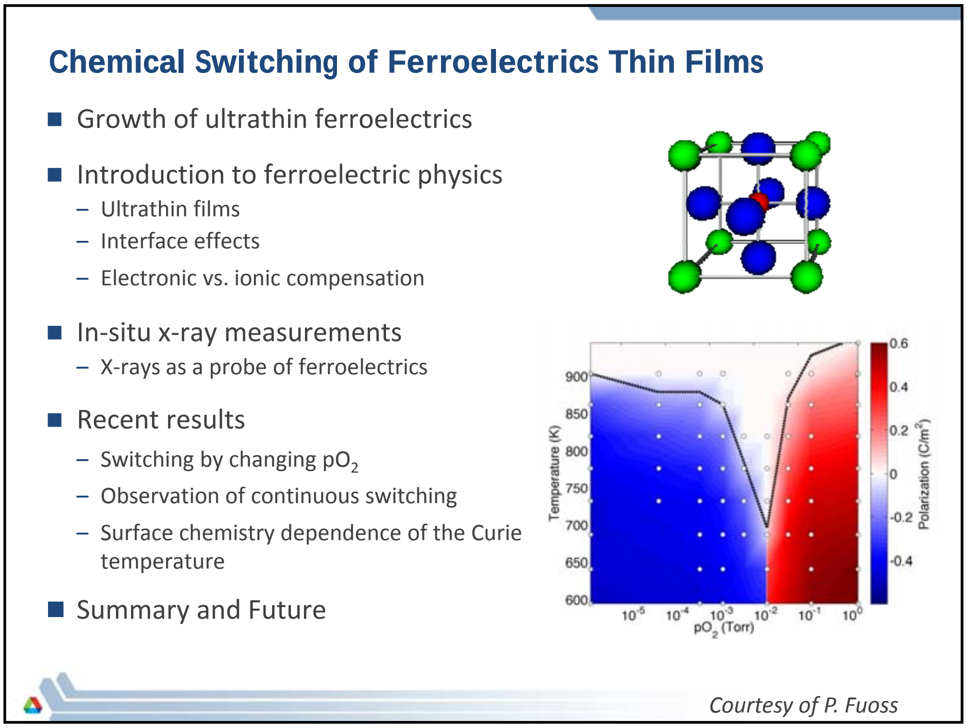
Courtesy of P. Fuoss



X-ray Impact: Grand Challenges of Materials Science

- Discovery of new materials and combinations with fantastic properties and functionality, e.g.
  - Highly efficient lighting, catalysts
  - High performance batteries and fuel cells
- *In situ* x-ray techniques are powerful tools
  - structure-property relations under operating conditions
  - materials synthesis
- Some exciting areas of current interest:
  - complex oxides
  - interfaces
  - proximity effects
- Ferroelectrics are excellent model systems to study these systems and effects

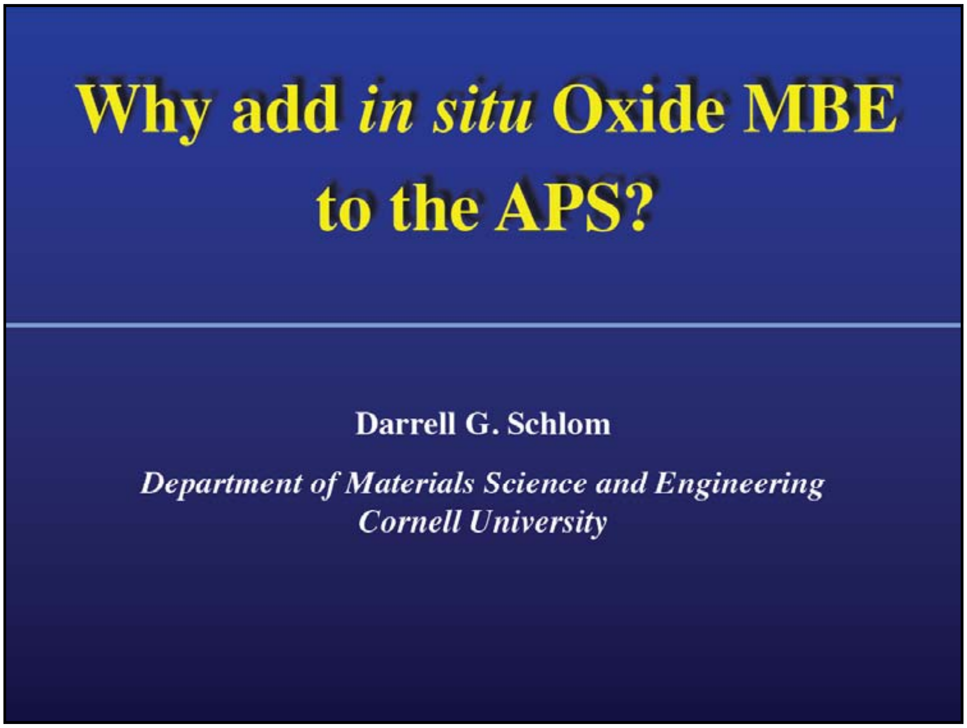
Courtesy of P. Fuoss



Chemical Switching of Ferroelectrics Thin Films

- Growth of ultrathin ferroelectrics
- Introduction to ferroelectric physics
  - Ultrathin films
  - Interface effects
  - Electronic vs. ionic compensation
- In-situ x-ray measurements
  - X-rays as a probe of ferroelectrics
- Recent results
  - Switching by changing pO_2
  - Observation of continuous switching
  - Surface chemistry dependence of the Curie temperature
- Summary and Future

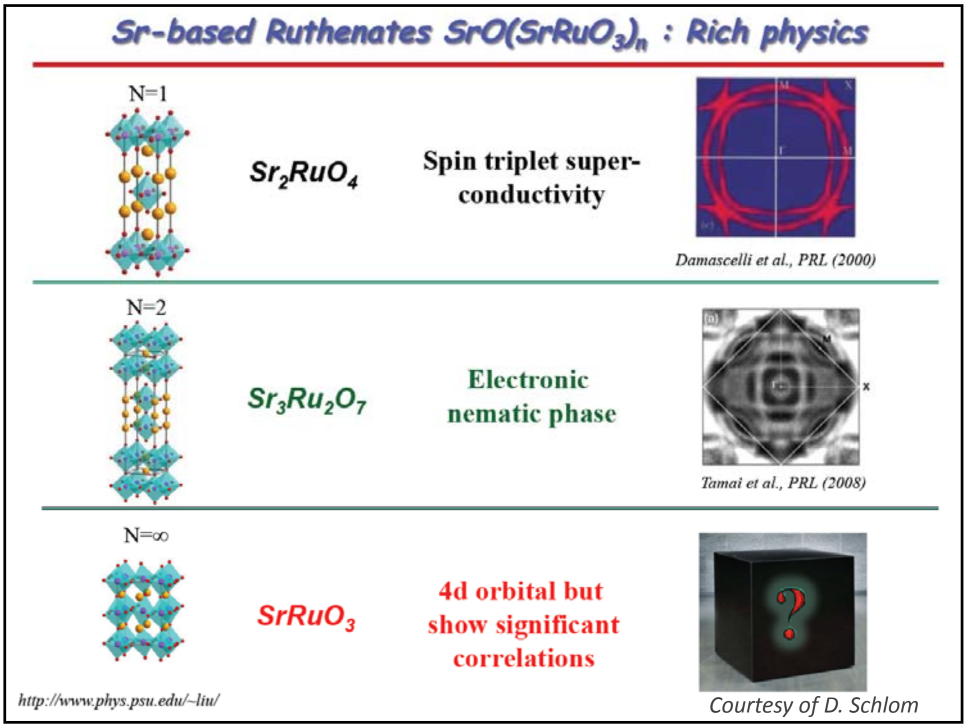
Courtesy of P. Fuoss



Why add *in situ* Oxide MBE to the APS?

Darrell G. Schlom

Department of Materials Science and Engineering
Cornell University

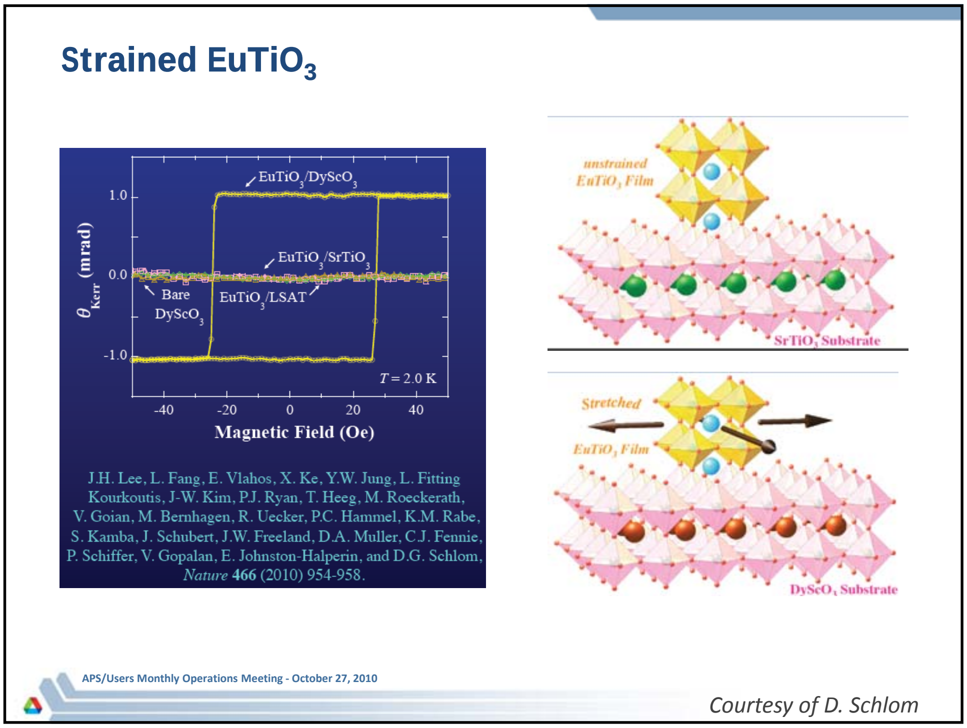


Sr-based Ruthenates SrO(SrRuO$_3$)$_n$: Rich physics

N=1	Sr_2RuO_4	Spin triplet super-conductivity	Damascelli et al., PRL (2000)
N=2	$Sr_3Ru_2O_7$	Electronic nematic phase	Tamai et al., PRL (2008)
N=∞	$SrRuO_3$	4d orbital but show significant correlations	

http://www.phys.psu.edu/~liu/

Courtesy of D. Schlom



Strained EuTiO$_3$

J.H. Lee, L. Fang, E. Vlahos, X. Ke, Y.W. Jung, L. Fitting Kourkoutis, J-W. Kim, P.J. Ryan, T. Heeg, M. Roeckerath, V. Goian, M. Bernhagen, R. Uecker, P.C. Hammel, K.M. Rabe, S. Kamba, J. Schubert, J.W. Freeland, D.A. Muller, C.J. Fennie, P. Schiffer, V. Gopalan, E. Johnston-Halperin, and D.G. Schlom, *Nature* **466** (2010) 954-958.

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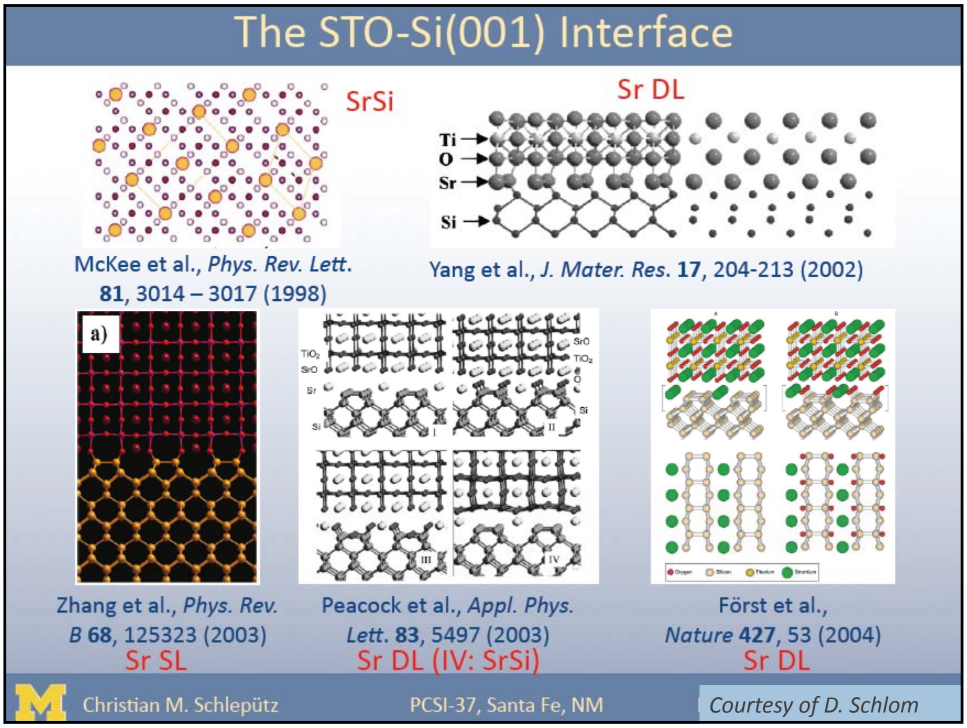
Courtesy of D. Schlom



The STO-Si(001) Interface

SrSi

McKee et al., *Phys. Rev. Lett.* **81**, 3014 – 3017 (1998)

Sr DL

Yang et al., *J. Mater. Res.* **17**, 204-213 (2002)

Zhang et al., *Phys. Rev. B* **68**, 125323 (2003)

Sr SL

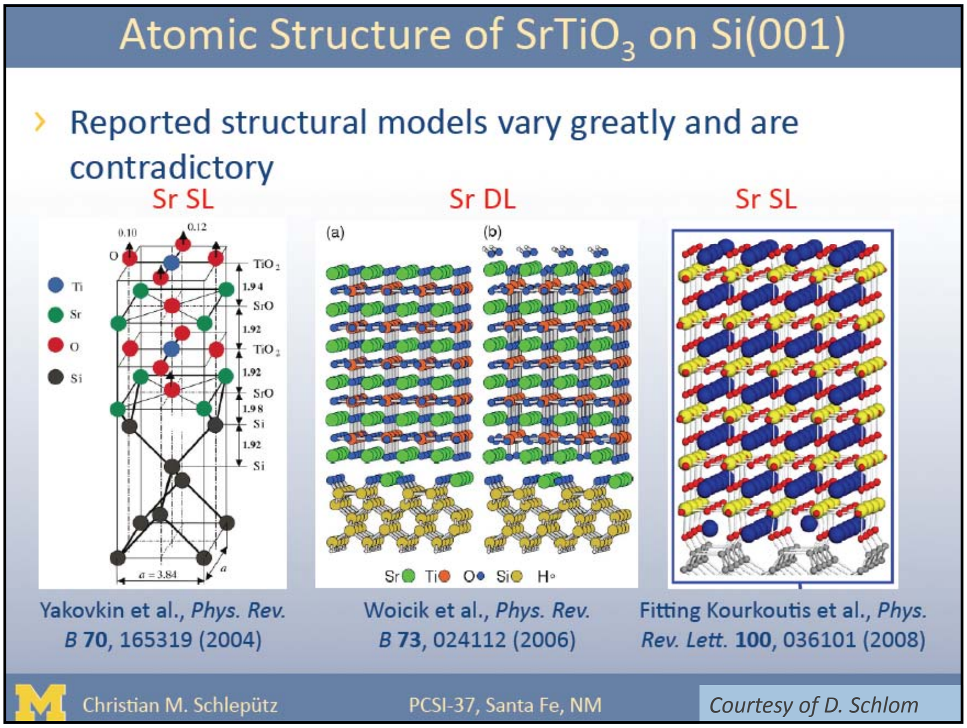
Peacock et al., *Appl. Phys. Lett.* **83**, 5497 (2003)

Sr DL (IV: SrSi)

Först et al., *Nature* **427**, 53 (2004)

Sr DL

Christian M. Schlepütz PCSI-37, Santa Fe, NM *Courtesy of D. Schlom*



Atomic Structure of $SrTiO_3$ on Si(001)

- Reported structural models vary greatly and are contradictory

Sr SL

Yakovkin et al., *Phys. Rev. B* **70**, 165319 (2004)

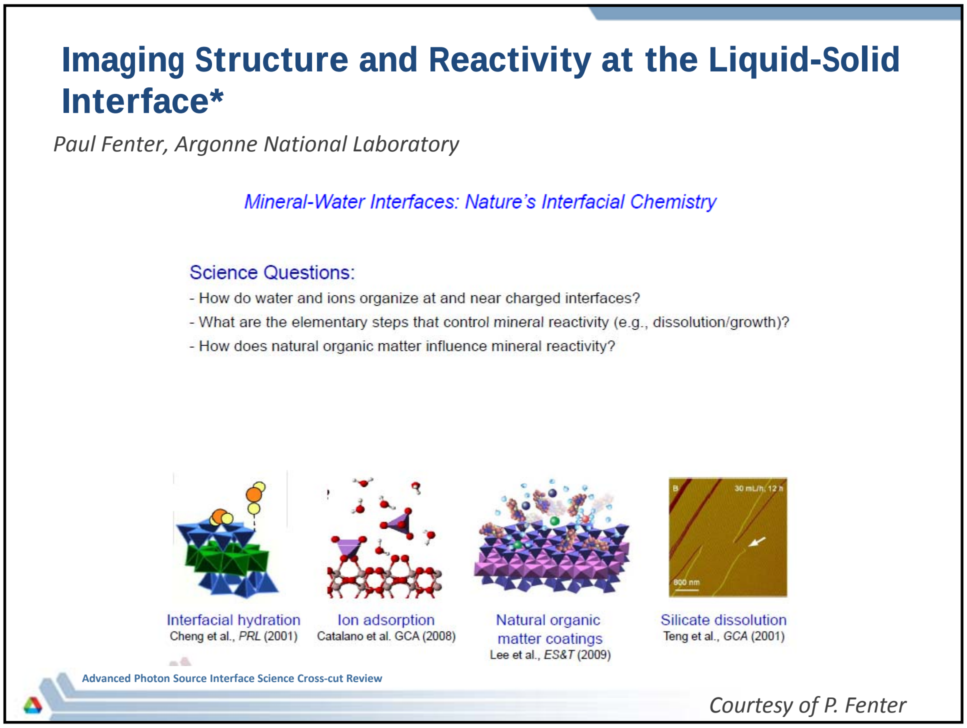
Sr DL

Woicik et al., *Phys. Rev. B* **73**, 024112 (2006)

Sr SL

Fitting Kourkoutis et al., *Phys. Rev. Lett.* **100**, 036101 (2008)

Christian M. Schlepütz PCSI-37, Santa Fe, NM *Courtesy of D. Schlom*



Imaging Structure and Reactivity at the Liquid-Solid Interface*

Paul Fenter, Argonne National Laboratory

Mineral-Water Interfaces: Nature's Interfacial Chemistry

Science Questions:
- How do water and ions organize at and near charged interfaces?
- What are the elementary steps that control mineral reactivity (e.g., dissolution/growth)?
- How does natural organic matter influence mineral reactivity?

Interfacial hydration
Cheng et al., *PRL* (2001)

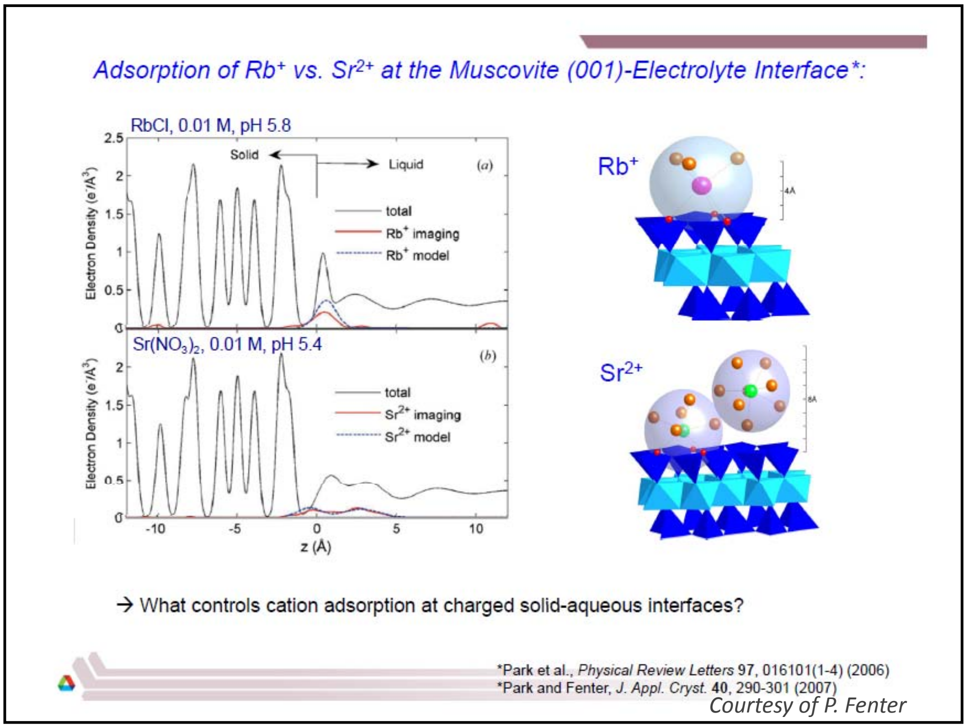
Ion adsorption
Catalano et al. GCA (2008)

Natural organic matter coatings
Lee et al., *ES&T* (2009)

Silicate dissolution
Teng et al., *GCA* (2001)

Advanced Photon Source Interface Science Cross-cut Review

Courtesy of P. Fenter

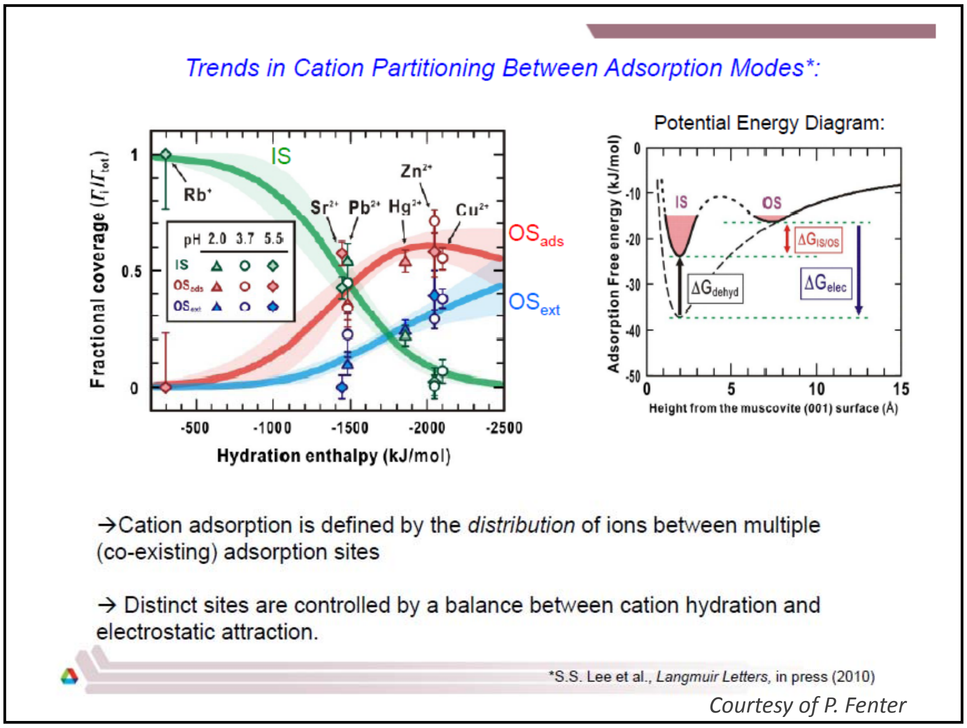


Adsorption of Rb^+ vs. Sr^{2+} at the Muscovite (001)-Electrolyte Interface:*

→ What controls cation adsorption at charged solid-aqueous interfaces?

*Park et al., *Physical Review Letters* **97**, 016101(1-4) (2006)
*Park and Fenter, *J. Appl. Cryst.* **40**, 290-301 (2007)

Courtesy of P. Fenter



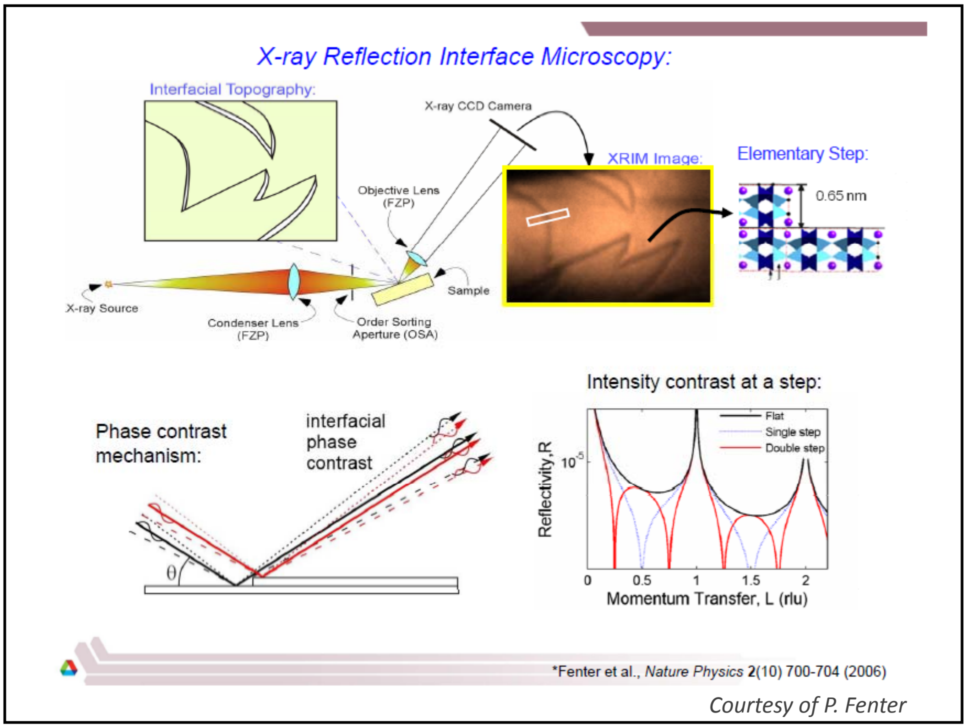
Trends in Cation Partitioning Between Adsorption Modes*:

→Cation adsorption is defined by the *distribution* of ions between multiple (co-existing) adsorption sites

→ Distinct sites are controlled by a balance between cation hydration and electrostatic attraction.

*S.S. Lee et al., *Langmuir Letters*, in press (2010)

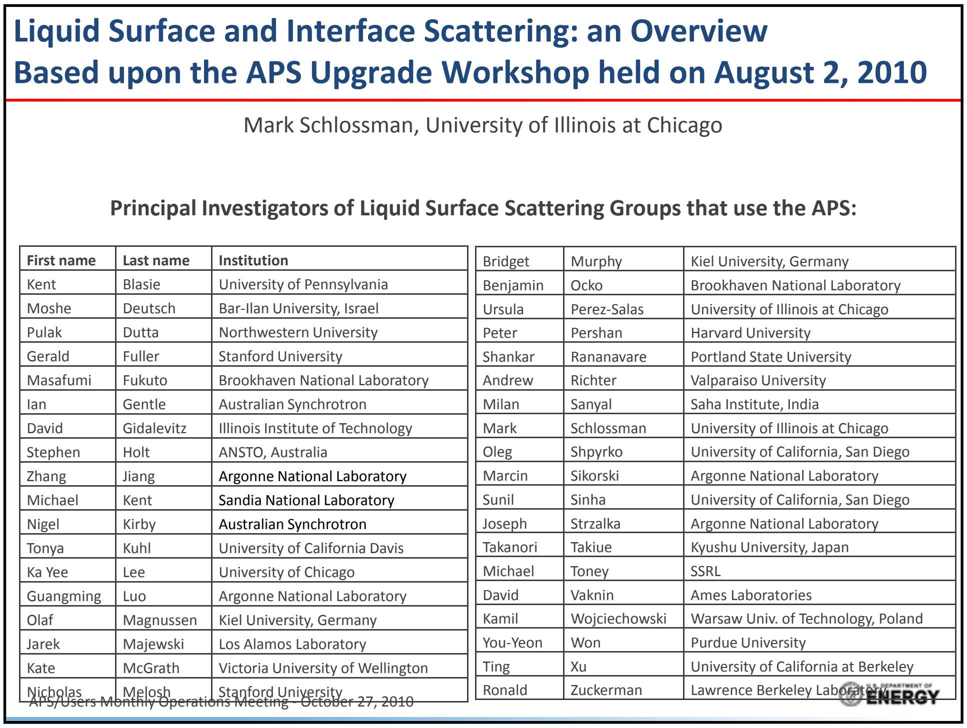
Courtesy of P. Fenter



X-ray Reflection Interface Microscopy:

*Fenter et al., *Nature Physics* **2**(10) 700-704 (2006)

Courtesy of P. Fenter

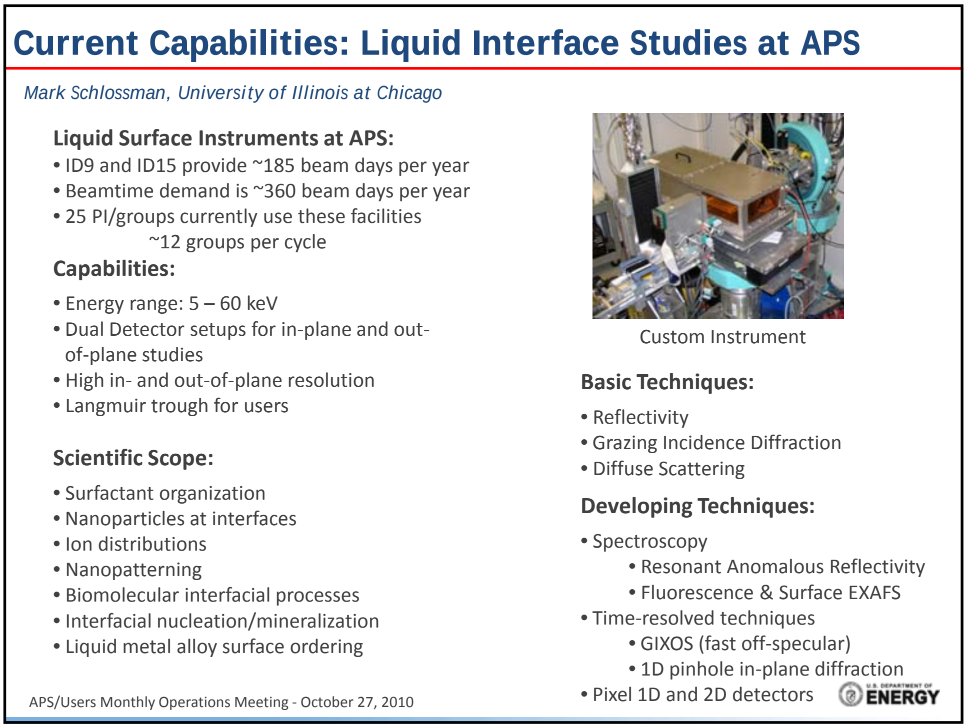


Liquid Surface and Interface Scattering: an Overview Based upon the APS Upgrade Workshop held on August 2, 2010

Mark Schlossman, University of Illinois at Chicago

Principal Investigators of Liquid Surface Scattering Groups that use the APS:

First name	Last name	Institution
Kent	Blasie	University of Pennsylvania
Moshe	Deutsch	Bar-Ilan University, Israel
Pulak	Dutta	Northwestern University
Gerald	Fuller	Stanford University
Masafumi	Fukuto	Brookhaven National Laboratory
Ian	Gentle	Australian Synchrotron
David	Gidalevitz	Illinois Institute of Technology
Stephen	Holt	ANSTO, Australia
Zhang	Jiang	Argonne National Laboratory
Michael	Kent	Sandia National Laboratory
Nigel	Kirby	Australian Synchrotron
Tonya	Kuhl	University of California Davis
Ka Yee	Lee	University of Chicago
Guangming	Luo	Argonne National Laboratory
Olaf	Magnussen	Kiel University, Germany
Jarek	Majewski	Los Alamos Laboratory
Kate	McGrath	Victoria University of Wellington
Nicholas	Melosh	Stanford University
Bridget	Murphy	Kiel University, Germany
Benjamin	Ocko	Brookhaven National Laboratory
Ursula	Perez-Salas	University of Illinois at Chicago
Peter	Pershan	Harvard University
Shankar	Rananavare	Portland State University
Andrew	Richter	Valparaiso University
Milan	Sanyal	Saha Institute, India
Mark	Schlossman	University of Illinois at Chicago
Oleg	Shpyrko	University of California, San Diego
Marcin	Sikorski	Argonne National Laboratory
Sunil	Sinha	University of California, San Diego
Joseph	Strzalka	Argonne National Laboratory
Takanori	Takiue	Kyushu University, Japan
Michael	Toney	SSRL
David	Vaknin	Ames Laboratories
Kamil	Wojciechowski	Warsaw Univ. of Technology, Poland
You-Yeon	Won	Purdue University
Ting	Xu	University of California at Berkeley
Ronald	Zuckerman	Lawrence Berkeley Laboratory



Current Capabilities: Liquid Interface Studies at APS

Mark Schlossman, University of Illinois at Chicago

Liquid Surface Instruments at APS:

- ID9 and ID15 provide ~185 beam days per year
- Beamtime demand is ~360 beam days per year
- 25 PI/groups currently use these facilities
  ~12 groups per cycle

Capabilities:

- Energy range: 5 – 60 keV
- Dual Detector setups for in-plane and out-of-plane studies
- High in- and out-of-plane resolution
- Langmuir trough for users

Scientific Scope:

- Surfactant organization
- Nanoparticles at interfaces
- Ion distributions
- Nanopatterning
- Biomolecular interfacial processes
- Interfacial nucleation/mineralization
- Liquid metal alloy surface ordering

Custom Instrument

Basic Techniques:

- Reflectivity
- Grazing Incidence Diffraction
- Diffuse Scattering

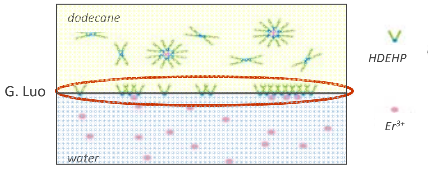
Developing Techniques:

- Spectroscopy
  - Resonant Anomalous Reflectivity
  - Fluorescence & Surface EXAFS
- Time-resolved techniques
  - GIXOS (fast off-specular)
  - 1D pinhole in-plane diffraction
- Pixel 1D and 2D detectors

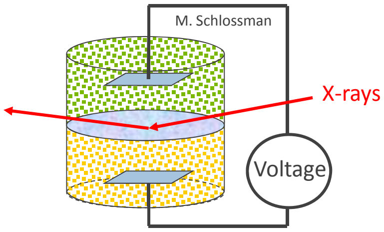
Upgrade Science: Solvent Extraction at Liquid Interfaces

Significance:
- separate metals and radioactive elements
- produce metals, clean up radioactive waste
- clean up metallic ions in polluted environments
- electrostatics at interfaces underlies many scientific and technological processes

Challenges:
- Structure and kinetics
- Ion Distributions
- Amphiphile Organization
- Ion – Amphiphile Interactions
- Kinetics of Ion Transfer
- Electrified Interfaces



Ion transfer occurs at interface, but structure is unknown



Key APS Upgraded capabilities:
- Small beams, high flux, high energy are essential for liquid/liquid interfaces currently only available at the ESRF
- Fast liquid-interface XR/GIXS for time-dependent studies.

Courtesy of M. Schlossman

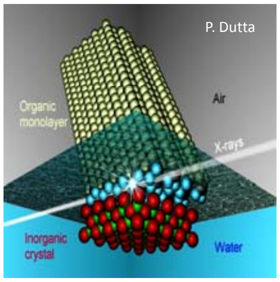
Upgrade Science: Directed Assembly for Tailored Functionality

Nucleation & Mineralization

Significance:
- Biominerals have enhanced strength with flexibility, sensing (magnetic, gravitational, optical), molecular repositories
- Bottom-up approach to the design of novel materials

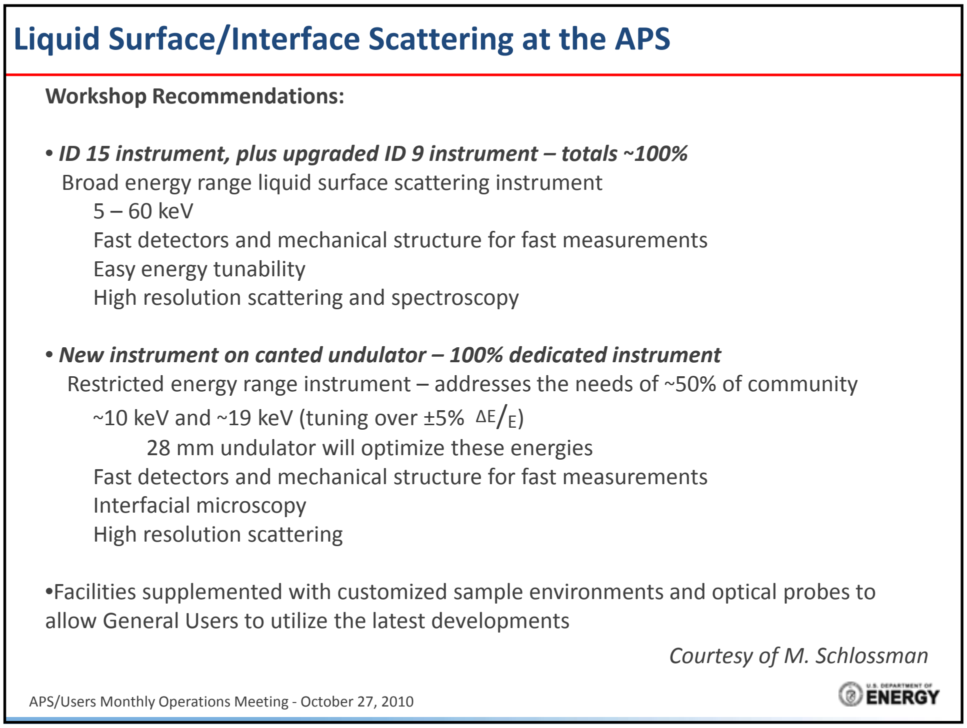
Challenges:
- Fast measurements – growth kinetics
- Inhomogeneous systems

Key APS Upgraded capabilities:
- Fast detectors



Liquid surfaces are a dynamic platform for nucleation

Courtesy of M. Schlossman



Liquid Surface/Interface Scattering at the APS

Workshop Recommendations:

- ***ID 15 instrument, plus upgraded ID 9 instrument – totals ~100%***
  - Broad energy range liquid surface scattering instrument
    - 5 – 60 keV
    - Fast detectors and mechanical structure for fast measurements
    - Easy energy tunability
    - High resolution scattering and spectroscopy
- ***New instrument on canted undulator – 100% dedicated instrument***
  - Restricted energy range instrument – addresses the needs of ~50% of community
    - ~10 keV and ~19 keV (tuning over ±5% $\Delta E/E$)
      - 28 mm undulator will optimize these energies
    - Fast detectors and mechanical structure for fast measurements
    - Interfacial microscopy
    - High resolution scattering
- Facilities supplemented with customized sample environments and optical probes to allow General Users to utilize the latest developments

Courtesy of M. Schlossman

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U.S. DEPARTMENT OF ENERGY

Design of Artificial Integral Membrane Proteins for Electro-Optical Biomolecular Materials Applications

Kent Blasie and
Shixin Ye, Jing Liu, Ting Xu, Venkata Krishnan,, Andrey Tronin
Department of Chemistry, University of Pennsylvania

Joseph Strzalka, Ivan Kuzmenko & Thomas Gog
APS/ANL

Michael Therien and
Sophia Wu, Ivan Miloradovic & Christopher Fry
University of Pennsylvania & Duke University

Hai-Lung Dai and Grazia Gonella
Temple University

Funding: DOE & NSF

Membrane Ion Channel Proteins Vectorially-Oriented within a Lipid Bilayer Membrane at the Solid-Vapor & Solid-Liquid Interfaces

Kent Blasie and
Jing Liu,, Andrey Tronin, Sanju Gupta
Department of Chemistry, University of Pennsylvania

Joseph Strzalka, Ivan Kuzmenko) & Thomas Gog
APS/ANL

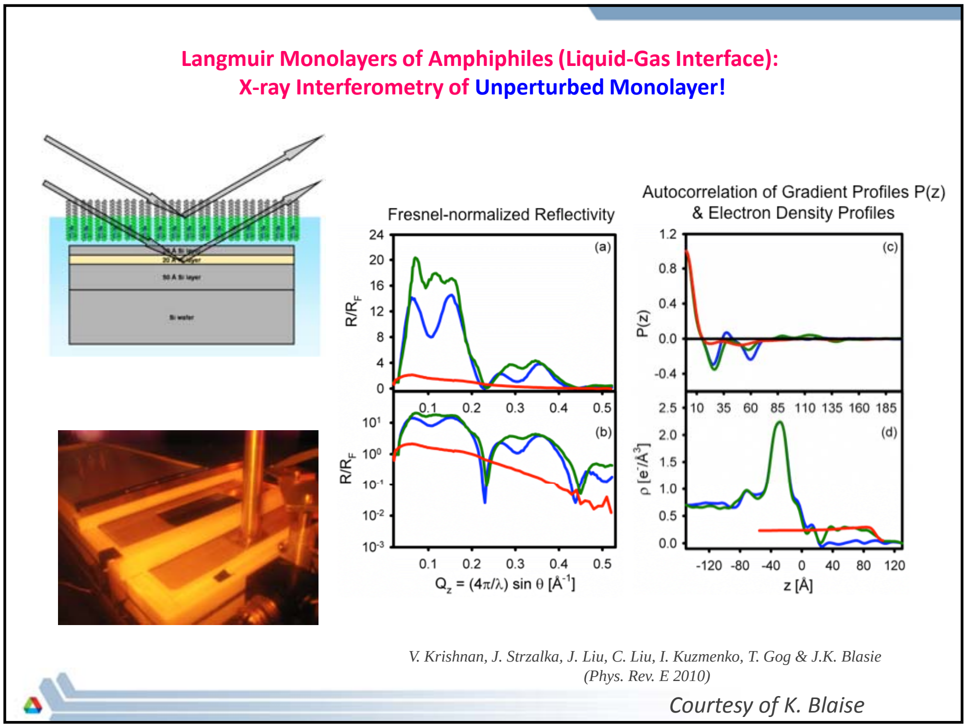
Kenton Swartz and *Dmitriy Krepkiy*
NINDS/NIH

Douglas Tobias and Stephen White
University of California Irvine

Funding: NIH

Penn
University of Pennsylvania

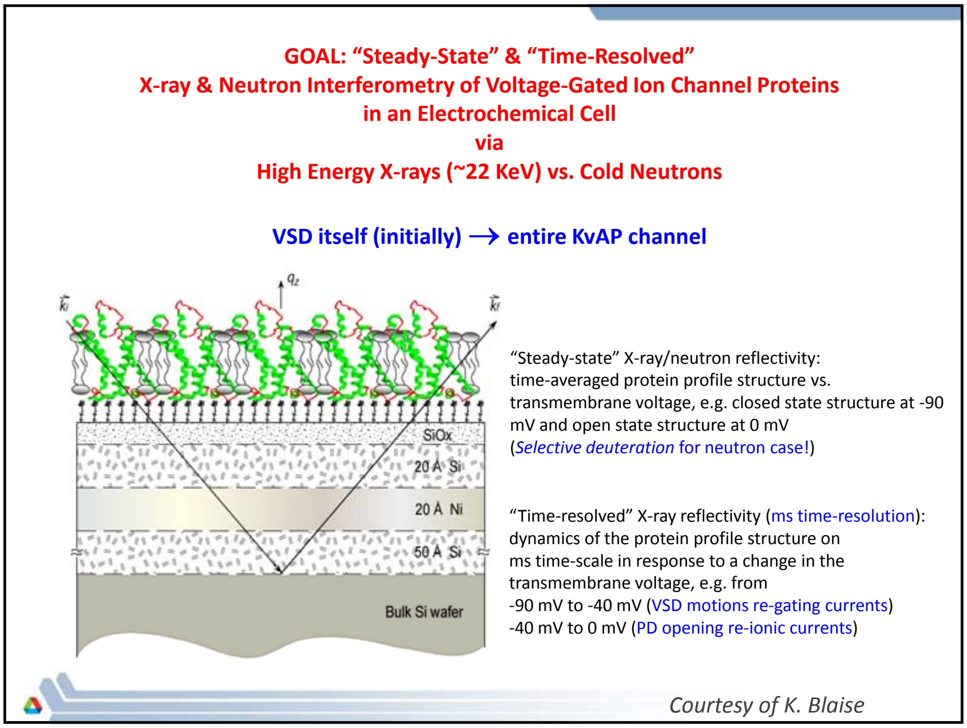
Courtesy of K. Blaise



Langmuir Monolayers of Amphiphiles (Liquid-Gas Interface): X-ray Interferometry of Unperturbed Monolayer!

V. Krishnan, J. Strzalka, J. Liu, C. Liu, I. Kuzmenko, T. Gog & J.K. Blasie
(Phys. Rev. E 2010)

Courtesy of K. Blaise



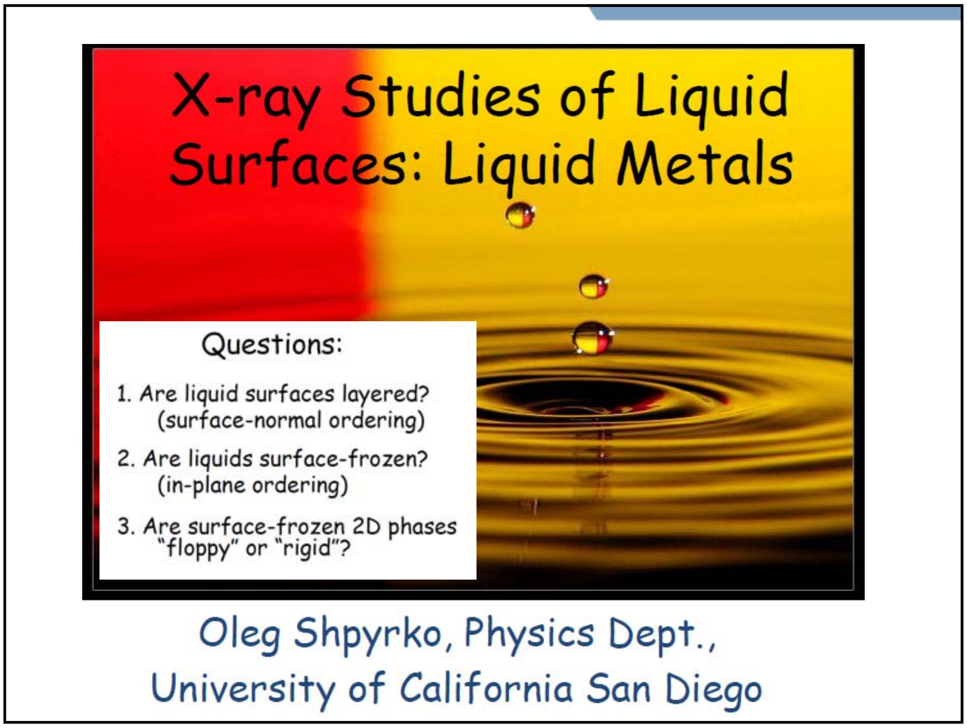
GOAL: "Steady-State" & "Time-Resolved" X-ray & Neutron Interferometry of Voltage-Gated Ion Channel Proteins in an Electrochemical Cell via High Energy X-rays (~22 KeV) vs. Cold Neutrons

VSD itself (initially) ⟶ entire KvAP channel

"Steady-state" X-ray/neutron reflectivity: time-averaged protein profile structure vs. transmembrane voltage, e.g. closed state structure at -90 mV and open state structure at 0 mV (*Selective deuteration* for neutron case!)

"Time-resolved" X-ray reflectivity (ms time-resolution): dynamics of the protein profile structure on ms time-scale in response to a change in the transmembrane voltage, e.g. from
-90 mV to -40 mV (VSD motions re-gating currents)
-40 mV to 0 mV (PD opening re-ionic currents)

Courtesy of K. Blaise

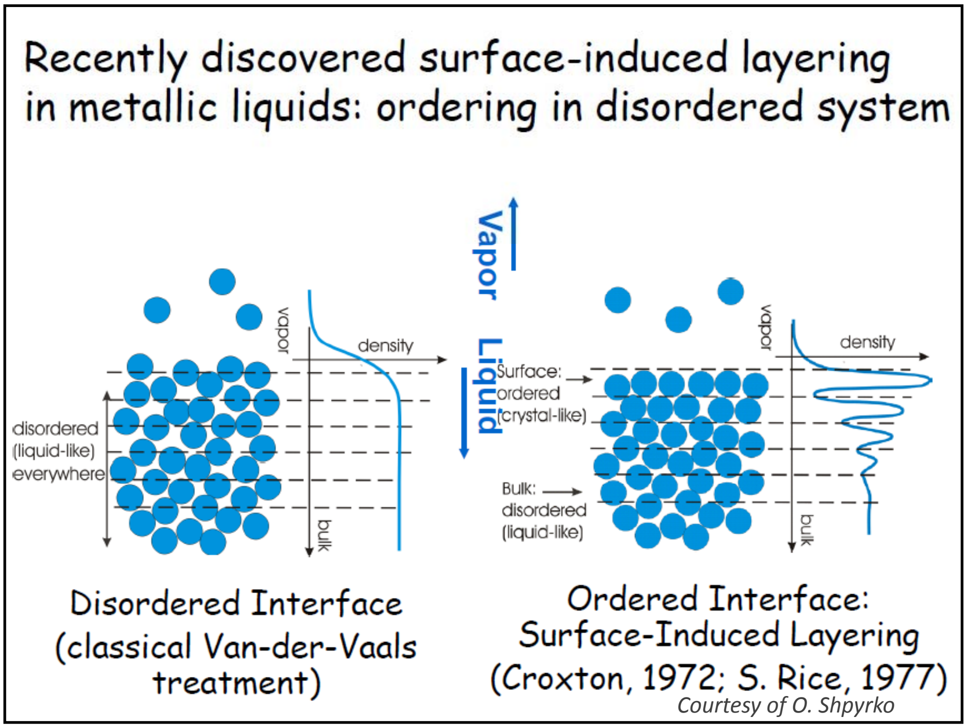


X-ray Studies of Liquid Surfaces: Liquid Metals

Questions:

1. Are liquid surfaces layered? (surface-normal ordering)
2. Are liquids surface-frozen? (in-plane ordering)
3. Are surface-frozen 2D phases "floppy" or "rigid"?

Oleg Shpyrko, Physics Dept.,
University of California San Diego

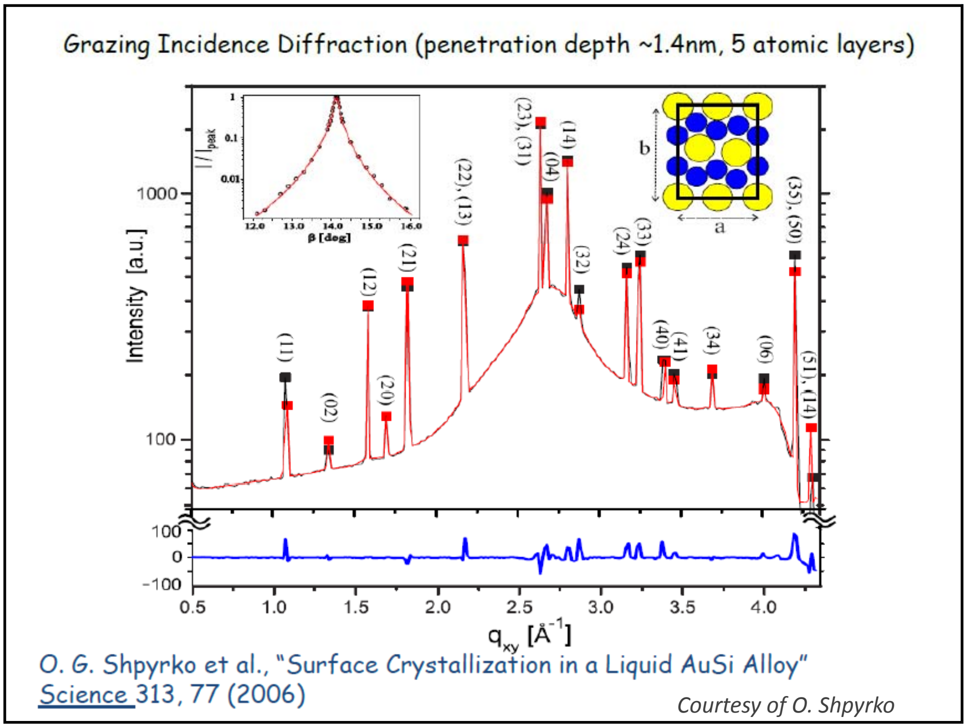


Recently discovered surface-induced layering in metallic liquids: ordering in disordered system

Disordered Interface (classical Van-der-Vaals treatment)

Ordered Interface: Surface-Induced Layering (Croxton, 1972; S. Rice, 1977)

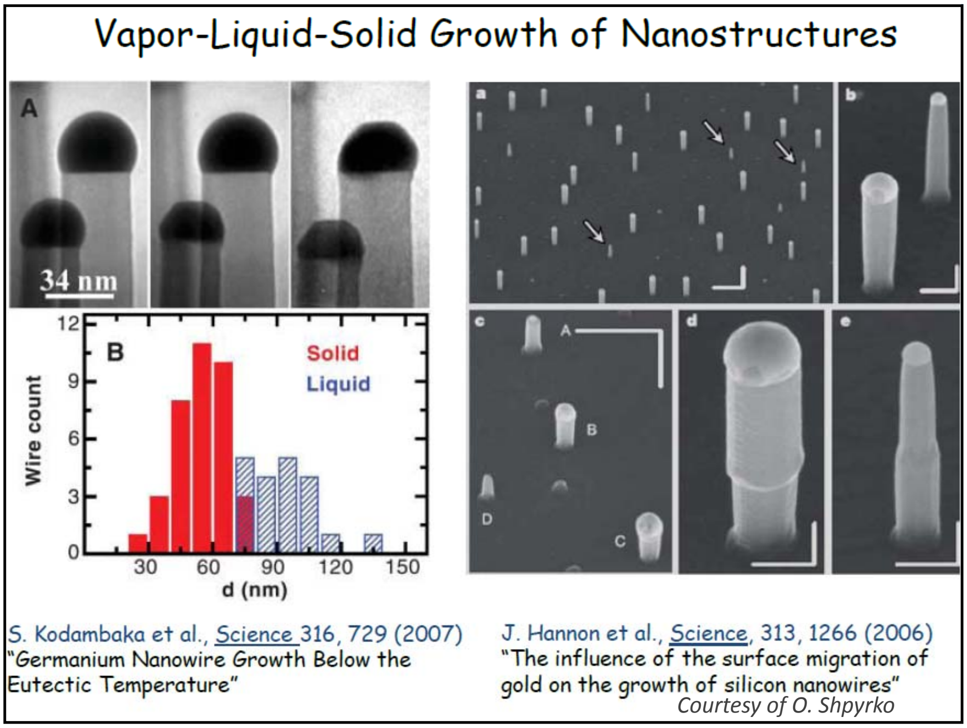
Courtesy of O. Shpyrko



Grazing Incidence Diffraction (penetration depth ~1.4nm, 5 atomic layers)

O. G. Shpyrko et al., “Surface Crystallization in a Liquid AuSi Alloy”
Science 313, 77 (2006)

Courtesy of O. Shpyrko

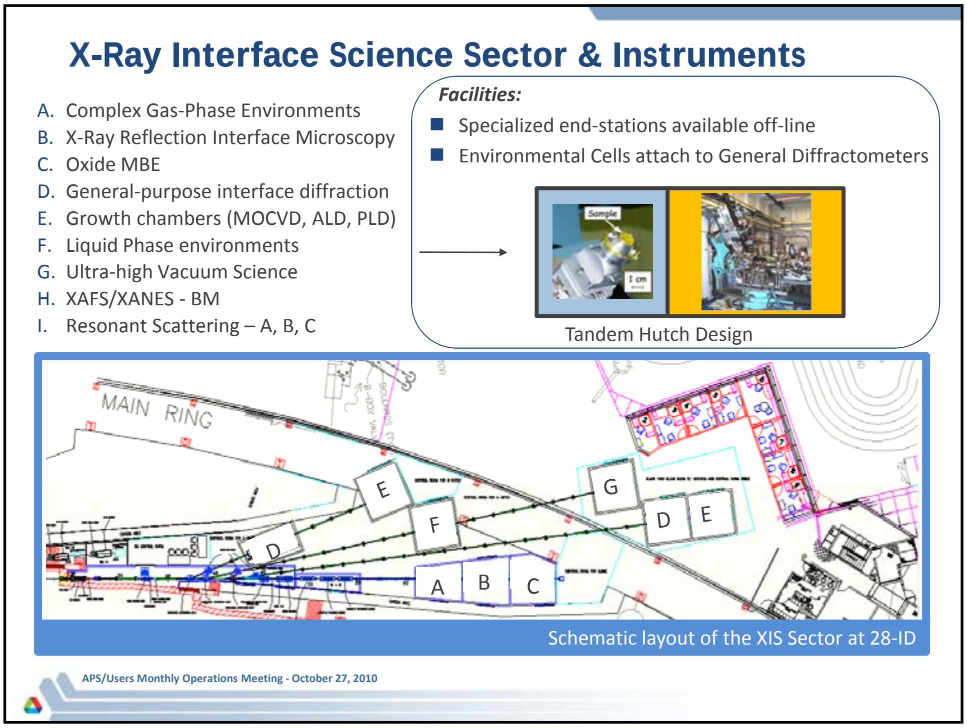


Vapor-Liquid-Solid Growth of Nanostructures

S. Kodambaka et al., Science 316, 729 (2007)
“Germanium Nanowire Growth Below the Eutectic Temperature”

J. Hannon et al., Science, 313, 1266 (2006)
“The influence of the surface migration of gold on the growth of silicon nanowires”

Courtesy of O. Shpyrko



X-Ray Interface Science Sector & Instruments

A. Complex Gas-Phase Environments
B. X-Ray Reflection Interface Microscopy
C. Oxide MBE
D. General-purpose interface diffraction
E. Growth chambers (MOCVD, ALD, PLD)
F. Liquid Phase environments
G. Ultra-high Vacuum Science
H. XAFS/XANES - BM
I. Resonant Scattering – A, B, C

Facilities:

- Specialized end-stations available off-line
- Environmental Cells attach to General Diffractometers

Tandem Hutch Design

Schematic layout of the XIS Sector at 28-ID

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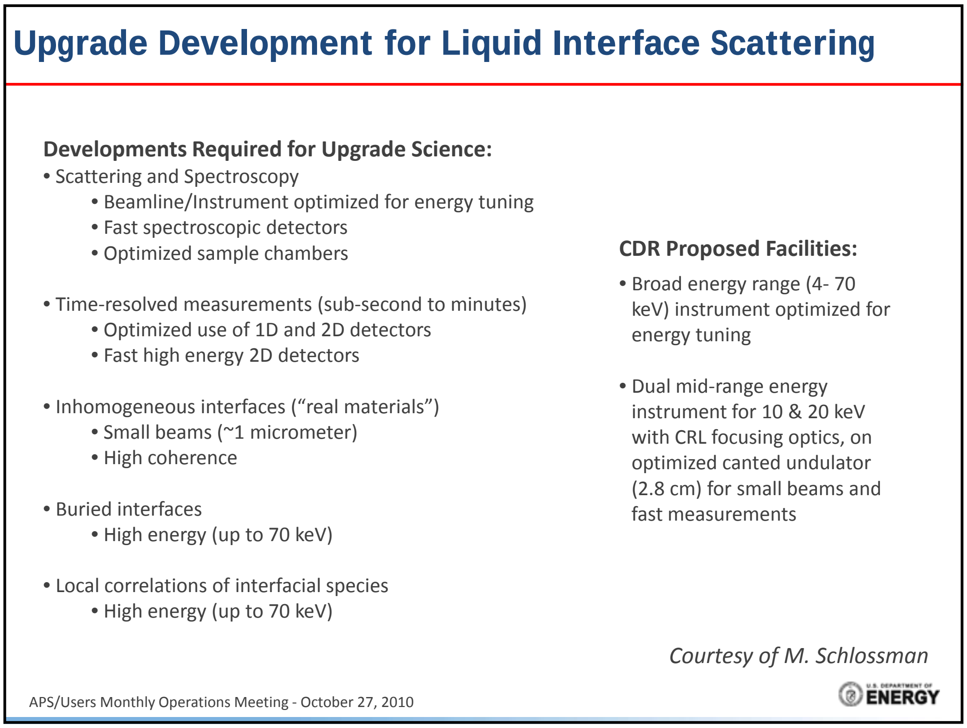

Upgrade Development for Liquid Interface Scattering

Developments Required for Upgrade Science:

- Scattering and Spectroscopy
  - Beamline/Instrument optimized for energy tuning
  - Fast spectroscopic detectors
  - Optimized sample chambers
- Time-resolved measurements (sub-second to minutes)
  - Optimized use of 1D and 2D detectors
  - Fast high energy 2D detectors
- Inhomogeneous interfaces (“real materials”)
  - Small beams (~1 micrometer)
  - High coherence
- Buried interfaces
  - High energy (up to 70 keV)
- Local correlations of interfacial species
  - High energy (up to 70 keV)

CDR Proposed Facilities:

- Broad energy range (4- 70 keV) instrument optimized for energy tuning
- Dual mid-range energy instrument for 10 & 20 keV with CRL focusing optics, on optimized canted undulator (2.8 cm) for small beams and fast measurements

Courtesy of M. Schlossman

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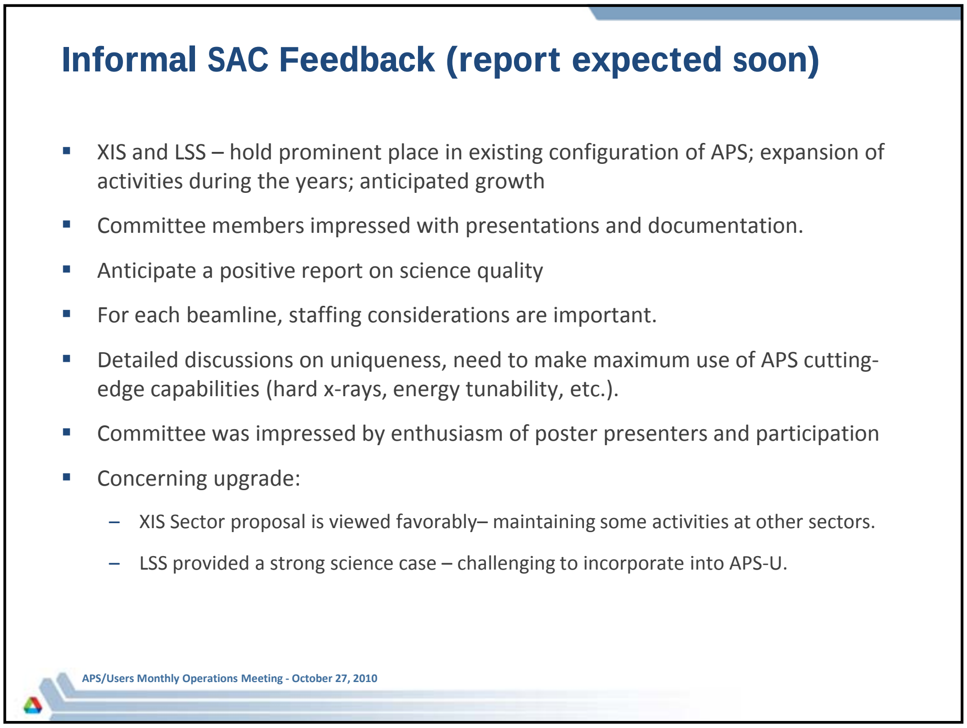
Overview of Beamlines for Interfaces in Complex Systems

- X-Ray Interface Science – ID Beamlines (28-ID)
  - One fully tunable canted Undulator beamline (4-40 KeV)
  - Fixed-energy Undulator beamlines – 3 branches: 10 keV, 30 keV, 30 keV
- X-Ray Interface Science – BM Beamline (28-BM)
  - Widely tunable beamline (5-35 KeV) for interface diffraction and spectroscopy
- Liquid Surface Scattering – ID Beamline
  - Dedicated liquid surface spectrometer on a tunable (3.5-30 KeV) ID beamline
  - Canted ID beamline to provide new dedicated liquid surface scattering instrument
- Expanded Resonant Interface Scattering (33-ID)
  - New optics and expanded hutch for robust resonant interface scattering
  - Canted ID beam line to provide independent operations of 33-ID-D and 33-ID-E
- Other activities related to “Interfaces in Complex Systems”:
  - Interfacial Magnetism (4-ID), High-energy Interface Diffraction (13-ID), GISAXS (8-ID, 12-ID), Surface Spectroscopy (20-ID)

Impact of APS-U on present SIS Activities

October 7 2010

4ID	John Freeland
5ID	Denis Keane
6ID	Phil Ryan
9ID	Ivan Kuzmenko
11ID	Klaus Attenhoffer
12ID	Paul Zschack
13ID	Peter Eng
15ID	Binhua Lin
20ID	Robert Gordon
33ID	Paul Zschack



Informal SAC Feedback (report expected soon)

- XIS and LSS – hold prominent place in existing configuration of APS; expansion of activities during the years; anticipated growth
- Committee members impressed with presentations and documentation.
- Anticipate a positive report on science quality
- For each beamline, staffing considerations are important.
- Detailed discussions on uniqueness, need to make maximum use of APS cutting-edge capabilities (hard x-rays, energy tunability, etc.).
- Committee was impressed by enthusiasm of poster presenters and participation
- Concerning upgrade:
  - XIS Sector proposal is viewed favorably– maintaining some activities at other sectors.
  - LSS provided a strong science case – challenging to incorporate into APS-U.