The SLAC (Interim) Director's Perspective

SSRL 50th Anniversary Celebration

Stephen Streiffer

April 20, 2023

U.S. DEPARTMENT OF ENERGY | Stanford University

SLAC NATIONAL ACCELERATOR LABORATORY

S.K. Streiffer Dissertation, Stanford (1993): Microstructural characterization of Y-Ba-Cu-O thin films: A comparison of lattice-matched and non-lattice-matched growth

- "To help investigate the symmetry and coherence of our ultrathin films [$YBa_2Cu_3O_{7-\delta}$ on MgO] and to further characterize the microstructure of these samples, a 2.4nm film was examined by Prof. B. Clemens of Stanford University using grazing incidence x-ray scattering (GIXS) at the ***Stanford Synchrotron Radiation Laboratory on Beamline 7-2***, using a wavelength of 0.15091 nm a constant reciprocal space L component of the grazing incidence scan of 0.1841 nm^{-1}."

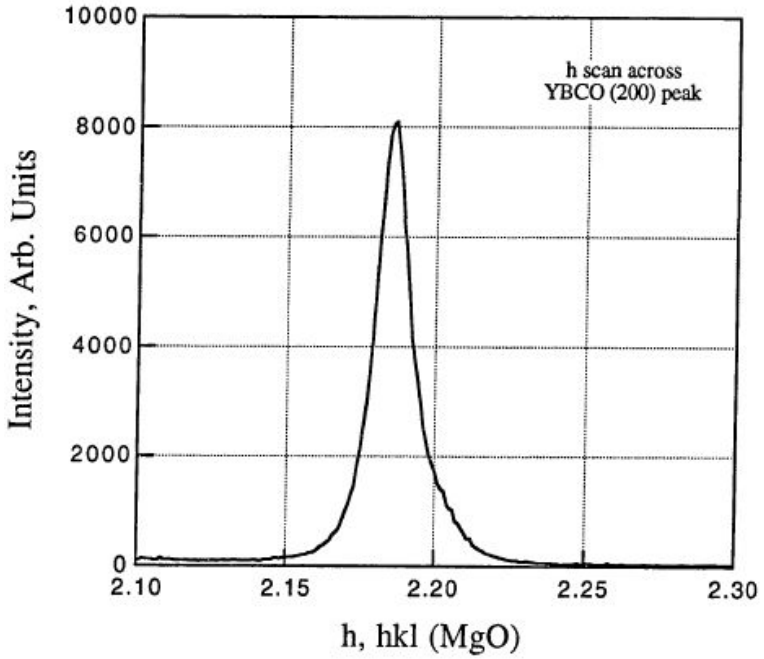


Figure 2.3: Reciprocal lattice GIXS scan of the $(200)_{YBCO}$ reflection from the 2.4 nm film, expressed in units of h along q = h00 of the MgO substrate.

Courtesy of P. Fuoss

PEP Undulators Gave Glimpse into 3rd Generation Future

1988: Bell Labs – SSRL collaboration uses world's brightest x-ray source to explore fundamentals of crystal growth with a custom growth system.

N OF X-RAY SOURCES

FLUX (photons / second)	INTENSITY (photons / mm² second)	BRIGHTNESS (photons / mm² mrad² second)
4×10¹¹†	4×10¹¹†	

Fuoss, Kisker and Brennan used x-rays to probe the complex chemical processes of industrial crystal growth. Contrary to conventional wisdom, they showed that atomically sharp interfaces were present during growth and that growth dynamics can be fo[illegible].

VOLUME 63, NUMBER 21 PHYSICAL REVIEW LETTERS 20 NOVEMBER 1989

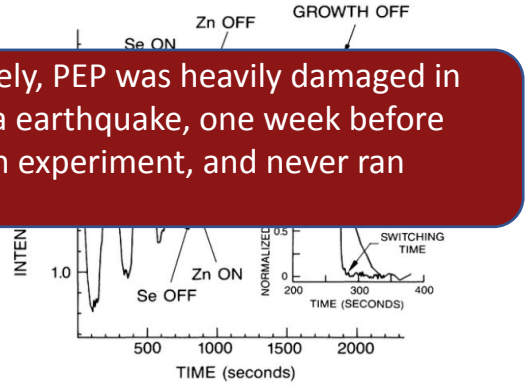
Atomic Nature of Organometallic-Vapor-Phase-Epitaxial Growth

P. H. Fuoss, D. W. Kisker, G. Renaud, and K. L. Tokuda
AT&T Bell Laboratories, Holmdel, New Jersey 07733

S. Brennan and J. L. Kahn
Stanford Synchrotron Radiation Laboratory, Stanford, California 94309

(Received 18 May 1989)

In situ x-ray scattering has been used to study a growing film (ZnSe on GaAs) during organometallic-vapor-phase epitaxy. This first *in situ* study of non-ultrahigh-vacuum growth revealed a surprisingly stable and well-ordered $p(2\times1)$ reconstruction during growth despite the presence of organic reaction by-products. Also, dramatic changes in the specular x-ray reflectivity were found while investigating transient kinetic effects during alternate-source epitaxy. These results demonstrate the power of *in situ* x-ray-scattering studies in the characterization of these complex processes.

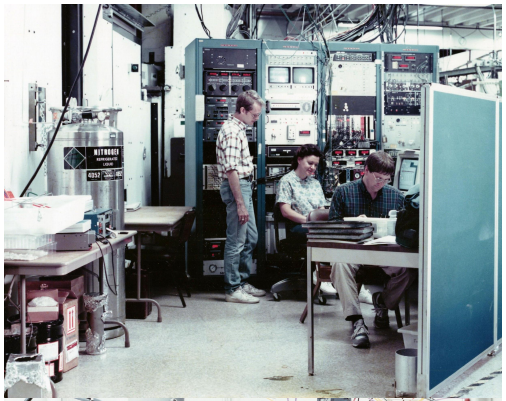


Unfortunately, PEP was heavily damaged in Loma Prieta earthquake, one week before next growth experiment, and never ran again.

Courtesy of P. Fuoss

But 25 Years of Ground-Breaking Experiments Followed

At SSRL BL 10-2 in 1991 and 92



- Layer-by-layer growth of GaAs
- Detailed studies of GaAs reconstructions
- Observation of diffuse scattering from growing islands
- Gas phase spectroscopy studies

BL 6-2 in 1993, 94 and 95

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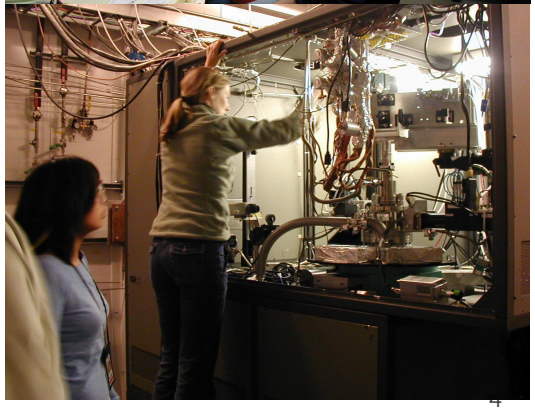
- Detailed studies of GaAs reconstructions
- Observation of diffuse scattering from growing islands
- Gas phase spectroscopy studies

- Detailed models of growth and growth modes based on diffuse scattering
- Correlation of synchrotron x-ray measurements with laboratory optical probes
- Studies of InGaAs growth

APS 12ID-D from 1997-2015



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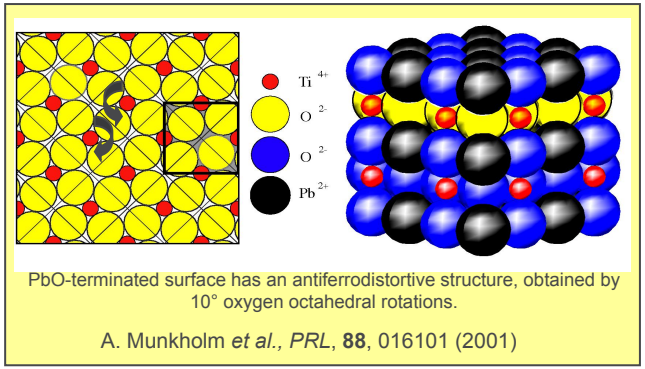
In-Situ Studies of Epitaxial $PbTiO_3$ Thin Films Grown by Metalorganic Chemical Vapor Deposition

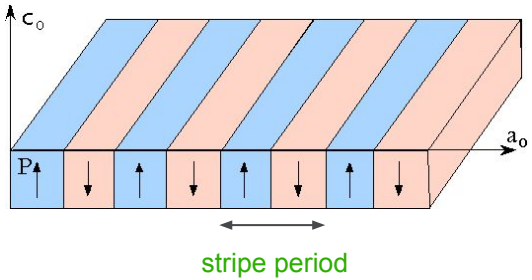
Stephenson, Streiffer, Thompson, Eastman, Fong, Fuoss et al.

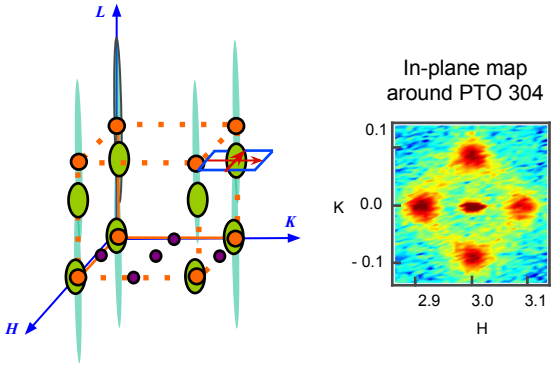
- Establish growth conditions for fully coherent, highly perfect Pb-terminated $PbTiO_3$ films on $SrTiO_3$
- First experimental observation of 180° polarization stripe domains
- First quantitative experimental verification of impact of strain on T_c in epitaxial ferroelectric films
- First quantitative determination of T_c as a function of film thickness



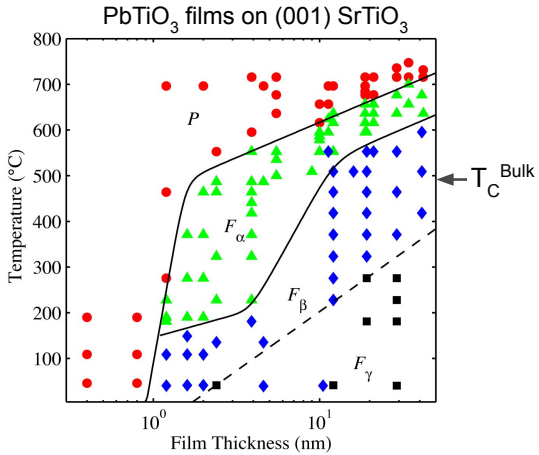
PbO-terminated surface has an antiferrodistortive structure, obtained by 10° oxygen octahedral rotations.

A. Munkholm *et al.*, *PRL*, **88**, 016101 (2001)





S.K. Streiffer et al., *PRL* **89**, 067601 (2002)

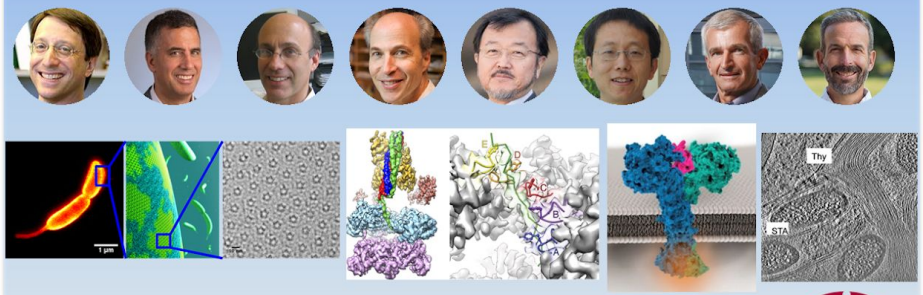


Fong et al. S*cience* 304, 1650 (2004)

A Successful Partnership: SSRL + Stanford University

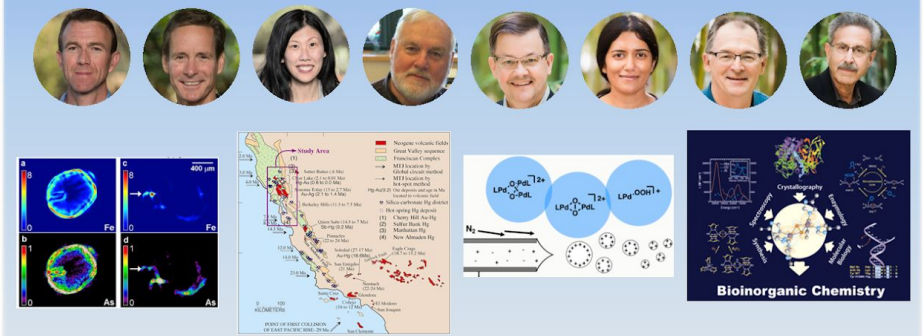
Representative Stanford PI's and Research

Biological & Medical Sciences

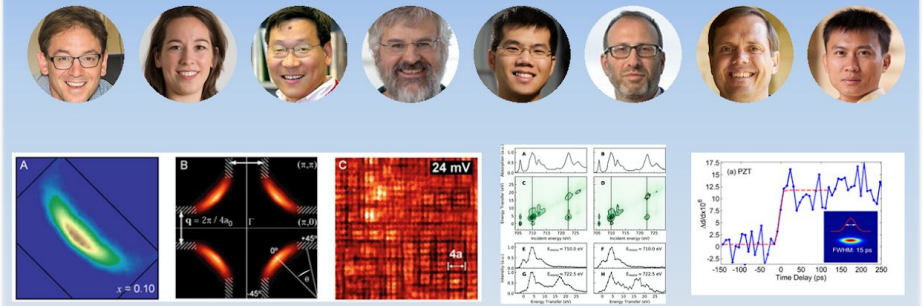


Chemical, Mechanical and Electrical Engineering

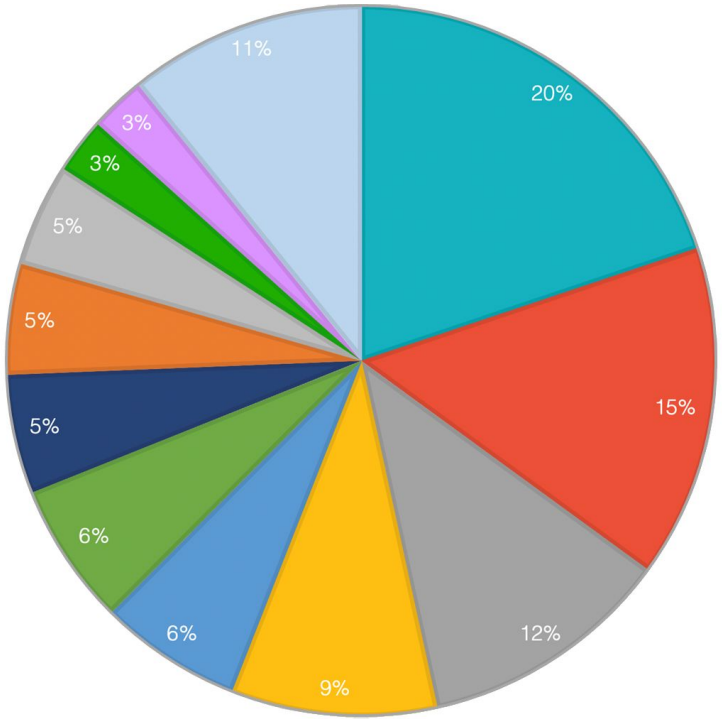
Earth Science & Chemistry



Physics, Materials & Energy Sciences



Stanford Users of SSRL



- Material Science & Engineering
- Chemical Engineering
- Chemistry
- Earth System Science
- Cell Physiology
- Physics
- Applied Physics
- Structural Biology
- Mechanical Engineering
- Biochemistry
- Engineering
- Other

280 Stanford researchers

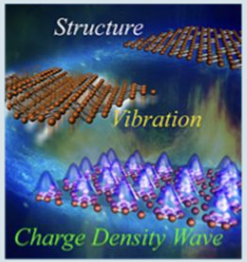
30 Academic departments

80 Stanford faculty members

150 User proposals

Developing unique capabilities and new science areas at SLAC

Quantum Materials

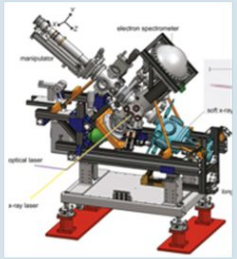


Resonant X-ray scattering program at SSRL built the foundation for unique experiments at LCLS

BL 17-2

New analyzer system for Fourier Transform RIXS at LCLS and SSRL to study Ultrafast Magnetism in 2D Layered Quantum Materials

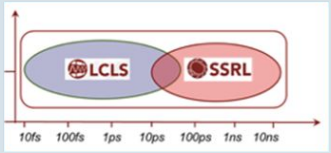
New X-ray Techniques

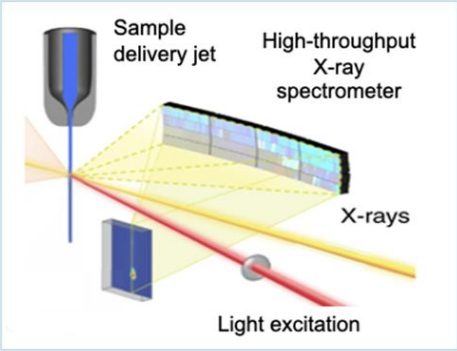


Testing new PAX system at SSRL prior to installation on LCLS qRIXS

Development of rapid-scan crystallography at SSRL BL12 informed the design of LCLS MFX

Chemical reactivity





Complementary timescales of LCLS and SSRL (fs to μs) enable holistic studies of photocatalytic dynamic phenomena upon light excitation

Leveraging collaborations between LCLS and SSRL