Students show off X-ray projects at CHESS



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Ithaca, New York. G-line scientist Arthur Woll organized a night of science, food and discussion for Cornell graduate students who do X-ray work at CHESS, the Cornell High Energy Synchrotron Source. G-line is a set of three high-intensity X-ray stations that were built by graduate students a few years ago, and continue to be maintained by students to serve the research needs of the Cornell Community. This symposium is held twice a year, giving the CHESS community an update on the accomplishments of the local faculty groups and student projects. This sixth meeting in the series was held Tuesday evening, January 23rd, 2007 in the Commons area of the Wilson Laboratory. Pizza, soft drinks, and coffee helped sustain the agenda!

Four students each gave 20-minute presentations. Kurt Andresen started the night with "Anomalous Small-angle X-ray Scattering (ASAXS) Study of Multivalent Ion-DNA Interactions." Kurt is a member of the biophysics graduate group of Lois Pollack, professor in the Applied and Engineering Physics (A&EP) department. He opened by noting that, despite its critical importance to biological functions, little experimental work directly explores ion-DNA interactions. In earlier work, Kurt and collaborators showed, using ASAXS, that a theory based on the Poisson-Boltzmann (PB) equation successfully explains the exchange between mono- and divalent cations surrounding DNA as the relative concentration of such ions is varied [1-3]. Kurt then presented preliminary data from ongoing experiments exploring the limits of the Poisson-Boltzmann equation as well as other theories.

John Ferguson followed with "Determining Growth Modes of SrTiO₃ (001) Homoepitaxy via Pulsed Laser Deposition (PLD) Using *In-situ* X-ray Reflectivity." John works in the

group of Joel Brock, professor and chair of the A&EP department. Homoepitaxial SrTiO₃ thin films were grown on single-crystal SrTiO₃ (001) via PLD, a process where a plume of material is rapidly ejected from the source by an energetic laser beam, and directed onto a heated substrate. The growth was monitored in real time by *in-situ* X-ray reflectivity measurements at the specular anti-Bragg position (Figure 1). John described measurements designed to map the transition between step-flow, layer-by-layer, and 3D growth as a function of substrate miscut. A cross-over from layer-by-layer to step-flow growth occurs when the distance between substrate steps approaches 20 nanometers, closely matching the distance between nucleating islands found using similar growth parameters in earlier work [4]. Both distances are determined by the mean diffusion length of adatoms on the surface following each pulse. An interesting feature of PLD as compared to traditional growth, the early-time anti-Bragg reflectivity oscillates as in layer-by-layer growth. A similar transition at a constant laser repetition rate occurs as the surface temperature is decreased.

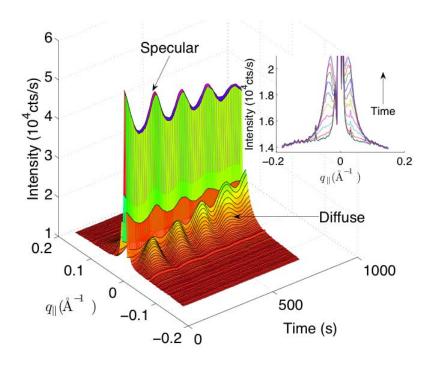


Figure 1. X-ray intensity measured around (0,0,0.2) during SrTiO₃ homoepitaxy at T=970 K, PO₂ = 10⁻⁵ Torr and layer pulse frequency = 0.1 Hz. An absorber attenuated the specular beam. Inset: Diffuse intensity during deposition of first half-monolayer. Each curve represents the integrated signal following a pulse. Reproduced from [4].

After a ten-minute "half-time" break, student Yi Liu presented "Surface Characterization of Novel Electrocatalysts for Fuel Cell Applications." Yi is a chemist studying with Héctor Abruña, professor and chair in the Chemistry and Chemical Biology department

and director of the Cornell Fuel Cell Institute

(http://abruna.chem.cornell.edu/cfci/home.html). Yi opened by discussing how ordered intermetallic compounds such as PtBi and PtPb are promising candidate electrocatalysts for the oxidation of small organic molecules, and have great potential applications in fuel cells [5,6]. Because these reactions take place at the electrode/solution interface, understanding the surface structure of electrodes and how they change during electrochemical activity should provide insight into improving catalytic performance. His group built an *in-situ* experimental cell and preliminary data was consistent with *exsitu* results (Figure 2). Measurements on PtBi and PtPb electrodes suggest that the nonplatinum metal leaches from the electrode surface when subjected to cleaning and activation treatments. For single crystal electrode surfaces, metallic Pt domains were formed when the electrode was subjected to 0.8V. The audience was engaged in a discussion of the relative orientation and commensurability of the overlayer versus substrate. Further results indicate that the leaching process is suppressed when formic acid, rather than sulfuric acid, was used as the electrolyte.



Figure 2. Electrochemical cell for *in-situ* X-ray characterization of catalyst surfaces. (Abruña group).

Last but not least, Hitesh Arora presented "Silicon Nanostructures from Block Copolymer Derived Thin Films." Hitesh is a chemical engineer in the research group of Uli Wiesner in Cornell's Materials Science and Engineering department. The focus of his research is fabricating organic-inorganic hybrid thin films and their application to silicon nanostructures. To this end a patterned aluminosilicate template is formed by spincoating a self-assembled mixture of PI-b-PEO block copolymers with aluminosilicate sol nanoparticles onto a silicon substrate and calcining at high temperatures [7,8]. The resulting honeycomb-like aluminosilicate films are typically 15-20 nanometers thick over an entire 100 millimeter silicon substrate and are characterized using AFM, SEM and GISAXS to obtain information on pattern quality. Next, amorphous silicon is deposited on the calcined film, and laser-annealed to crystallize in the pores of the amorphous aluminosilicate film. Finally, the aluminosilicate is removed using hydrofluoric acid. Subsequent TEM analysis shows that the deposited nano-pillars crystallize in registry with the atoms of the substrate (Figure 3). This method may become a cost-effective and rapid way to realize silicon nanostructures down to the tens of nanometers regime without the use of traditional lithographic techniques.

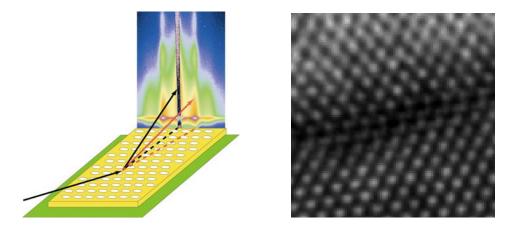


Figure 3. (left) Schematic geometry of the GISAXS data collection from nanopatterned thin films (from D. Smilgies). (right) SEM image of registry of silicon atoms in pillars, top, with substrate below. (Wiesner group).

At the evening's conclusion, many audience members commented on the high quality of the presentations and discussion, in addition to appreciating that the evening stayed on schedule! The students and faculty all expressed hopes for the upcoming year and looked forward to hearing updated reports at the next symposium in early fall.

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