Examples of Research with CaPeRS – the Canadian Photoemission Research Microscope

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History

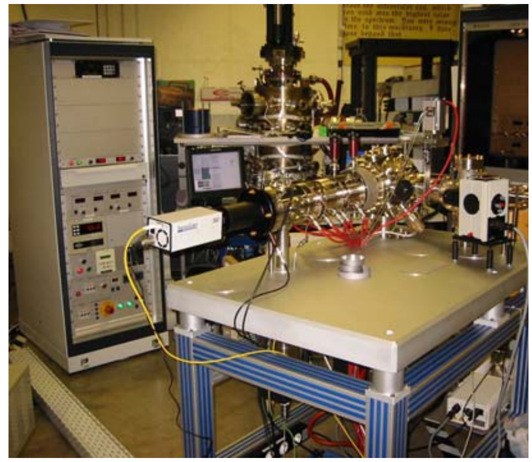

Fig. 1 PEEM Imaging column with magnetic lenses. Resolution: 8 nm (Hg arc lamp); Field of view: 2 - 175 µm, base pressure: < 2 x 10-10 Torr; Sample temperature: 100 to 2200 K.

The Canadian Photoemission electron Research Spectromicroscope (CaPeRS) microscope (**Fig. 1**) is a magnetic lens based Elmitec Photoelectron Emission Microscope (PEEM) currently located at the Synchrotron Radiation Center (U. Wisconsin Madison). The CaPeRS microscope combines the high spatial resolution of PEEM microscopy (20 - 50 nm) with the chemical sensitivity of x-ray absorption spectroscopy. This microscope is currently being used for a wide range of projects including: chemical imaging of phase segregated polymer blends, selective protein attachment to surfaces, patterned biomaterials, meteorites, mineral surfaces, and the development of X-ray natural circular dichroism as a contrast mechanism. This document sketches some recent results from the commissioning and the scientific program of this microscope.

The temperature of the sample in the Elmitec PEEM can be controlled between 100 K and 2800 K. A holder allowing imposition of a magnetic field is being developed. A well equipped preparation chamber has been funded and should be available by the end of 2003 at SRC.

CaPeRS will emigrate to the spectromicroscopy beam line at the Canadian Light Source, when that beamline is fully operational, probably in fall 2004. At CLS the default source will be a state-of-the-art elliptically polarized undulator (which has full control of linear and elliptical polarization) and a high performance plane grating monochromator spanning 100 to 2000 eV. Since CaPeRS is mobile, it will also be capable of use on any beam line at the CLS, thus accessing photon energies from the UV to the hard X-ray.

Research Examples

A. Characterization of instrument performance

(Urquhart, Elmitec)

Elmitec guarantees a spatial resolution below 10 nm when using a Hg lamp with their instrument. **Fig.2** is a high magnification image of Pb islands deposited on a patterned Si substrate. The sharpness of the Pb islands is about 8-9 nm, thus indicating that the instrument performs to specification.

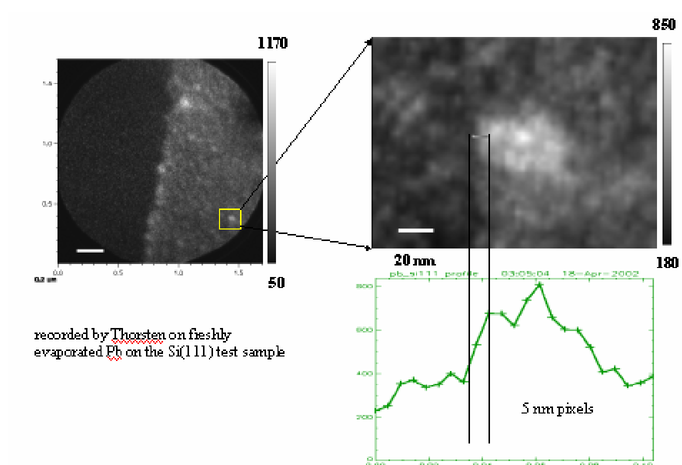

Fig. 2 Demonstration of sub-10 nm resolution – three days from installation !! (April 2002)

B. Biomaterial optimization : mapping proteins on patterned polymers
(Hitchcock, Morin, Urquhart)

The PhD thesis project of Cynthia Morin is to show that PEEM can detect monolayer protein on patterned surfaces. Although much effort had been spent a the ALS PEEM-2 instrument, this project met many set backs, in part because of radiation damage associated with the very high flux at the ALS. These results are from one of the first examinations of Cynthia's test system, fibrinogen (a blood protein) on annealed, spun cast, $PS_{0.3}PMMA_{0.7}$ blend (**Fig. 3**). The relatively low flux of the SRC beamlines turned out to be an advantage in demonstrating protein detection by PEEM Since those measurements, even higher quality results have been obtained with a recently improved ALS PEEM-2 system.

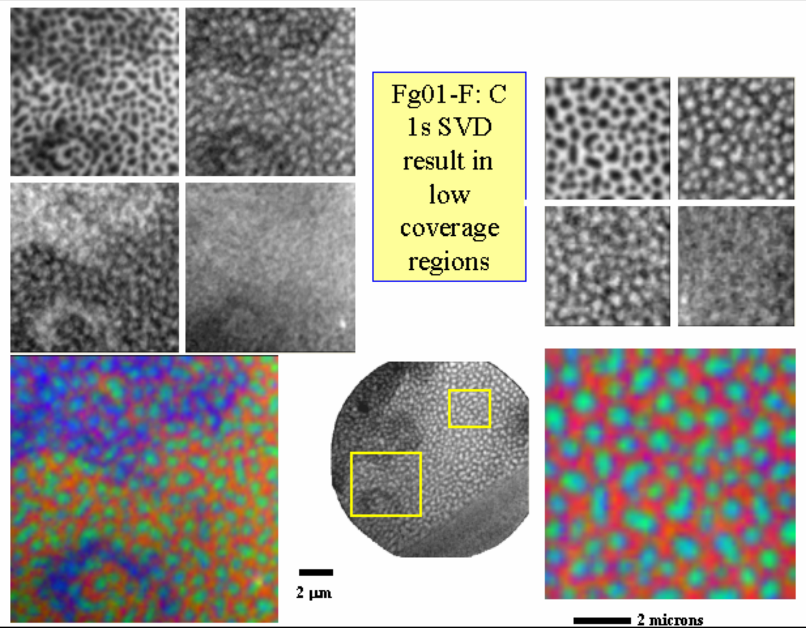

Fig. 3 Maps derived from C 1s image sequences of 2 low-coverage areas of fibrinogen adsorbed from a 0.01mg/ml solution onto a spun cast PS/PMMA blend. The 4 images above the color map are PS , PMMA, Fg and residual component maps. Composite: (**PS**, **PMMA**, **protein**) (CSRF-SGM Nov-02)

C. Striped patterns in thermal processing of high-Tc superconductors (Kaznacheyev, M. Abrecht)

It is known, that in-vacuum thermal annealing leads to oxygen loss in HTSC ($YBa_2Cu_3O_7$). But the structure and the steps the system undergo during this process, especially at the microscopic level, are less understood. This question is not only of technological relevance, but might bring insight into phase separation, electron lattice interaction, and possibly, additional information on incommensurate spin and charge ordering, known as "stripes" and other "collective excitation", which lead to spatial inhomogeneity. To study this, we have performed PEEM measurements on high quality 123 thin films. Preliminary data (July 2002, SRC), reveals formation of new "white island" patterns with submicron size. Unfortunately, the SRC NIM beamline did not provide enough flux to make a qualitative assignment for the new phase, based on work function offset. New experiments are underway.

In vacuum annealing (Hg lamp)

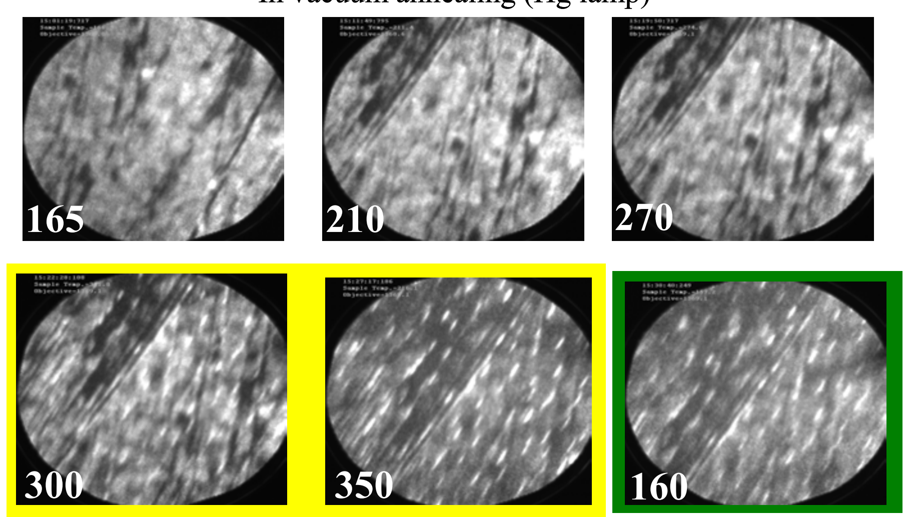

Fig. 4 Thermal transformation of 123-YBCO/ $SrTiO_3(100)$ prepared by laser ablation of sintered $YBa_2Cu_3O_{6+x}$ as tracked by Hg lamp PEEM images (SRC NIM, July, 2002) (20 micron field of view).