Secondary Electron Emission Microscopy of Langmuir Blodgett Thin Films

S. Christensen, U.D. Lanke, B. Haines, S.E. Qaqish, M.F. Paige, S.G. Urquhart
Department of Chemistry, University of Saskatchewan

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PRINCIPAL CONTACT:

S.G. Urquhart
Associate Professor
University of Saskatchewan
stephen.urquhart@usask.ca

Introduction

The structure and composition of phase-separated Langmuir Blodgett monolayer films was characterized with Secondary Electron Emission Microscopy (SEEM), X-ray Photoemission Electron Microscopy (X-PEEM) and Atomic Force Microscopy (AFM). SEEM is sensitive to work function and potentially the local order in organic thin films, while X-PEEM provides for chemical characterization of the domains.

Experimental Details

Phase separated Langmuir Blodgett (LB) monolayer films were prepared from mixtures of arachidic acid (AA; $C_{19}H_{39}COOH$) and perfluorotetradecanoic acid (PA; $C_{13}F_{27}COOH$) (2:1 ratio, see reference 1 for experimental details). X-PEEM provides high lateral spatial resolution and is directly sensitive to the elemental and chemical (e.g. functional group) composition of these ultrathin films through the chemical sensitivity of NEXAFS spectroscopy. AFM provides high-resolution imaging, both in terms of lateral and vertical (height) film topography. SEEM provides structural and electronic information through work function and electron scattering effects. The combination is used for chemical mapping of the phase-separated domains in the monolayer film.

X-PEEM and SEEM experiments were performed using the Canadian Photoemission electron Research Spectromicroscope (CaPeRS) (Elmitec GmbH), mounted on the Spectromicroscopy beamline 10ID-1. An energy filter in this X-PEEM microscope enables energy filtered imaging and spatially resolved photoelectron spectroscopy.

Science

AFM microscopy of the phase separated LB film (2AA:1PA) is presented in Figure 1. As observed previously [2], the discontinuous domains are ~6 Å higher than the continuous domains, consistent with the increased length of the AA chains. NEXAFS spectra of these LB-films, obtained with spatial resolution in the X-PEEM microscope, showed a higher F *1s* signal from the continuous domains. C *1s* and F *1s* NEXAFS spectra recorded at the CLS were confirmed using the lower dose PEEM-2 microscope at the Advanced Light Source, Lawrence Berkeley National Laboratory [1].

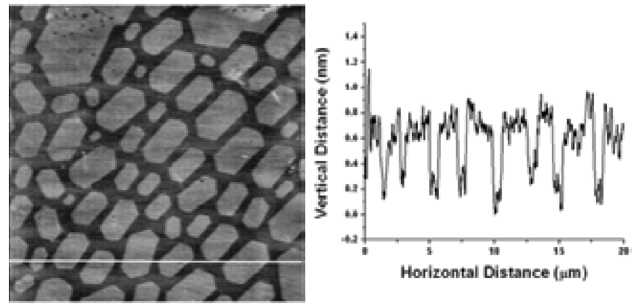

Figure 1: AFM height mode image (20 μm x 20 μm, contact mode in air) and cross-sectional analysis of 2AA:1PA LB film deposited on silicon.

Figure 2 presents secondary electron photoemission spectra from continuous and discontinuous domains in the 2AA:1PA films; this is the spectra of the low kinetic energy electrons emitted by the sample. The displacement of the secondary emission curve is consistent with the lower workfunction expected for AA films relative to the PA films [3].

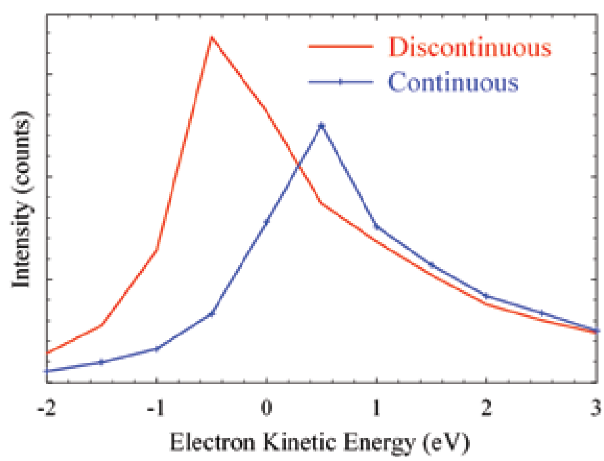

Figure 2: Spatially resolved secondary electron photoemission spectra of 2AA:1PA LB film, recorded with photon energy of 695 eV.

Secondary electron emission can also provide useful image contrast. Figure 3 presents SEEM images recorded at different electron kinetic energies. A contrast inversion can be seen, and the domain size expands slightly in the middle image. Previous secondary electron spectroscopy studies of alkanes have shown large secondary electron energy shifts during melting [4], suggesting that SEEM may be sensitive to molecular order. Further study is required to understand this effect.

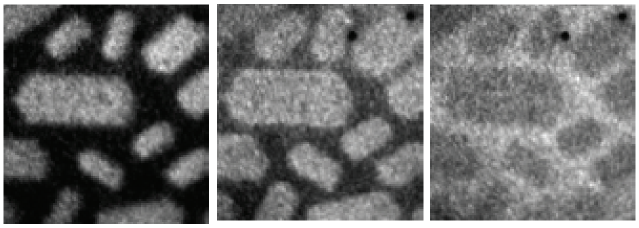

Figure 3. SEEM images recorded at different values of the relative electron kinetic energy, with photon energy of 695 eV. Left: -0.5 eV; Centre: 0 eV; Right: 0.5 eV.

Conclusion

Our SEEM and X-PEEM results directly confirm previous AFM measurements that suggested that the discontinuous domains are enriched in arachidic acid, whereas the surrounding continuous domain is mostly perfluorotetradecanoic acid. As SEEM images can be acquired rapidly at a fixed photon energy, this method may provide a low-dose method for characterizing ultra-thin films.

References

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