

# G-Line Director's Report

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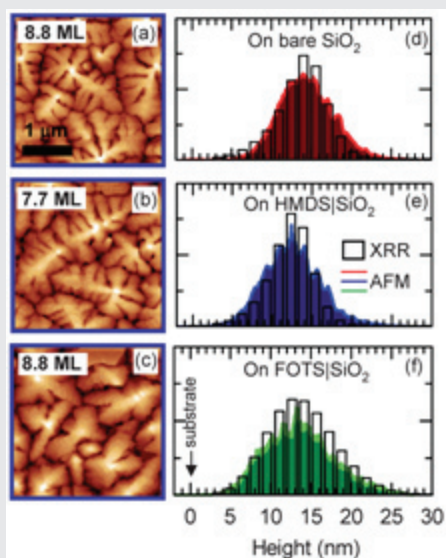
G-line has had another banner year, both in terms of the exciting forefront science that has been accomplished and in the truly excellent graduate students who have been trained and performed their research there. For example, the Cornell Center for Materials Research's Interdisciplinary Research Group studying the growth of thin-films of chemically complex materials is operating both pulsed laser and supersonic molecular beam (SMB) deposition systems in the G3 experimental station. They are using them to perform *in situ*, real-time x-ray structural studies of the growth processes occurring during deposition. These research programs involve several Cornell faculty research groups (faculty, post-docs, graduate students, and undergrads) and several of the CHESS staff scientists. The program studying the growth of thin films of organic semiconductors via SMB deposition provides an excellent example of the value of both *in situ* studies and the immersion of post-docs and graduate students in the G-line facility. Supervised by Professors George Malariás (Materials Science), James Engstrom (Chemical Engineering), Joel Brock (Applied Physics) and Arthur Woll (CHESS/G-line), post-doctoral research associates Aram Amassian and Sukwon Hong and graduate students Vladimir Pozdin, Tushar Desai, and John Ferguson deposited thin films of pentacene onto SiO<sub>2</sub> a gate dielectric, treated with hexamethyldisilazane (HMDS) and fluorinated octyltrichlorosilane (FOTS). The morphology of pristine, as-deposited thin films was determined during growth by *in situ* real-time X-ray reflectivity and was measured again, *ex situ*, by atomic force microscopy (AFM) following aging at room temperature in vacuum, in

N<sub>2</sub> atmosphere, and in ambient air. The films deposited on HMDS and FOTS undergo significant reorganization under vacuum or in N<sub>2</sub> atmosphere<sup>1</sup>. The changes observed indicate a de-wetting behavior. This work highlights the propensity of small-molecule thin films to undergo significant molecular-scale reorganization at room temperature when kept in vacuum or in N<sub>2</sub> atmosphere after deposition, and provides a cautionary note to anyone investigating the behavior of organic electronic devices and the relationship of *ex situ* studies to the initial growth of ultra-thin molecular films.

The SMB deposition system was designed and built over the past several years by graduate students in the Engstrom research group. The data collection was a collaboration led by Drs. Amassian and Hong with intensive involvement by the graduate students. Arthur Woll's development of the analytical tools necessary to extract reliable coverage data from the time-dependent x-ray reflectivity data was crucial to the success of this project. Dr. Amassian has recently accepted a faculty position at the brand new King Abdullah University of Science and Technology (KAUST) but continues to collaborate with G-line through the KAUST center at Cornell.

## References

1. A. Amassian, V.A. Pozdin, T.V. Desai, S. Hong, A.R. Woll, J.D. Ferguson, J.D. Brock, G.G. Malliaras, and J.R. Engstrom; "Post-deposition Reorganization of Pentacene Films Deposited on Low-Energy Surfaces", *Journal of Materials Chemistry* **19**, 5580-5592 (2009)



AFM images (3×3 μm<sup>2</sup>) obtained *ex situ* from ~8 ML pentacene thin films deposited from a supersonic source (E<sub>i</sub> = 2.5 eV) on (a) bare SiO<sub>2</sub> and on SiO<sub>2</sub> treated with (b) HMDS and (c) FOTS. The continuous (color filled) curves were calculated directly from the AFM images. The (hollow) bars were calculated from the X-ray measurements. (a) and (b) were obtained after aging 12 hours in vacuum and 30 days in air, (c) was obtained after 6 hours in vacuum and 60 days in air. Figure from Ref. [1].