Crystallisation mechanism of organic semiconductor thin film during solution deposition

Jing Wan¹, Randall L. Headrick¹, Detlef-M. Smilgies², Yang Li¹

¹ Department of Physics, University of Vermont, Vermont 05405, USA
² Cornell High Energy Synchrotron Source(CHESS), Ithaca, New York 14853, USA

The small-molecule organic semiconductor, 2,7-dioctyl[1]benzothieno[3,2-b][1]benzothiophene (C₈-BTBT) has great potential in organic electronic applications due to its promising electronic properties. These properties are greatly influenced by the crystalline packing of molecules within each layer, which may depend on the processing methods and conditions. Here we develop thin-films of C₈-BTBT with controllable grain size and film morphology, using a simple solution-processing method, hollow capillary writing. Under very high writing speed (>20 mm/s) we achieve carrier mobility in thin-film transistors as high as 2.6 cm²/Vs. To understand the crystallization mechanisms in this very interesting new regime, we use real-time synchrotron x-ray scattering combined with optical video microscopy during the deposition of organic thin films under different substrate heating temperatures. It is well established that at low writing speeds the crystallization follows the writing direction and yields large grains, with the crystallize phase occurring directly from the isotropic liquid state. However, at high writing speeds and elevated substrate temperatures, we observe a different sequence of crystallization. In this case, a layered liquid-crystalline type structure precedes inter-layer ordering, which indicates the formation of an intermediate state during the crystallization process.