Controlling Grain Growth in Solution-Processed Organic Semiconductors for Thin Film Transistors

Stephanie Lee*, Chang Su Kim, Enrique Gomez, and Yueh-Lin (Lynn) Loo
Department of Chemical Engineering, Princeton University

John E. Anthony
Department of Chemistry, University of Kentucky

Cheng Wang and Alex Hexemer
Lawrence Berkeley National Laboratory, Berkeley, CA

Poster (2:20 PM)

The extent of crystallinity and grain size of the active layer in organic thin-film transistors (OTFTs) plays an important role in determining device performance and is sensitive to both inherent material properties and processing conditions during device fabrication. Transistors using triethylsilylethynyl anthradithiophene (TES-ADT) [1], a solution-processable molecule that has emerged in recent years as a promising candidate for electronic device applications, exhibit large differences in device mobility depending on the crystallinity of the film [2]. As-spun TES-ADT films are amorphous and devices demonstrate mobilities around 0.002 cm^2/V-s. Upon exposure to 1,2-dichloroethane vapor, the film crystallizes, and this simple annealing step improves the device mobility two orders of magnitude to values around 0.1 cm^2/V-s. Nucleation in the film, however, tends to occur on defects and dust particles, making it difficult to reproducibly control grain size in films from batch to batch.

In this work, we present a novel method of controlling grain size in solution-processed TES-ADT films through the addition of fractional amounts of fluorinated 5,11-bis(triethylsilylethynyl) anthradithiophene (FTES-ADT) [3], ranging from 0.6 to 1.25 mol%. FTES-ADT acts as heterogeneous nuclei to initiate the crystallization of TES-ADT during solvent-vapor annealing. We have found that the grain size in these films follows an exponential dependence on the concentration of FTES-ADT over a range of three orders of magnitude, from 29 μm to 2700 μm. Using this method to controllably alter the grain size in the active layer of bottom-contact TFTs, we examined the impact of grain boundary density on device mobility. For films with an average grain size of 29 μm, device mobility in bottom-contact OTFTs was measured to be 0.05 cm^2/V-s, whereas for films with an average grain size of 2700 μm, the device mobility was measured to be 0.35 cm^2/V-s. The relationship between device mobility and grain size follows closely to a composite mobility model, which assumes a high intrinsic mobility through grains and a low mobility through grain boundaries.

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[2] K.C. Dickey, J.E. Anthony, and Y.L. Loo, *Advanced Materials* 18, 1721 (2006).
[3] S. Subramanian, S.K. Park, S.R. Parkin, V. Podzorov, T.N. Jackson, J.E. Anthony, *Journal of the American Chemical Society* 130, 2706 (2008).