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Hot communication: Observation of intermediate-range order in a nominally amorphous molecular semiconductor film

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Héctor Abruña tells *Journal of Materials Chemistry* about his hot communication.

1. Can you briefly describe what you achieved in this article?
The performance of devices such as organic light emitting diodes (OLEDs) that depend on thin films are strongly correlated with the film's microstructure. While single crystal films generally exhibit the highest transport rates and quantum efficiencies, there are no cost effective methods to deposit such films over large areas. The use of polycrystalline films presents great challenges due to their high surface roughness and the fact that grain boundaries serve as efficient trapping and recombination sites resulting in dramatic degradation of performance. The use of amorphous films is most attractive because of their ease of deposition and because their hopping mode of transport is often sufficient for OLEDs and photovoltaic devices. Thus, an understanding of the local structure of nominally amorphous films could provide a great deal of insight as to how film morphology affects device performance. Our results provide a first characterization of a nominally amorphous molecular semiconductor thin film, and indicate that ordering actually occurs on an intermediate range, with crystalline domains in the range of a few nanometers. Such intermediate range order has been a hot topic in the community studying glassy materials in recent years.

2. Could you explain the significance of your article to the non-specialist?
So far, amorphous materials in the Organic Electronics community have been identified by the absence of diffraction. However, being able to probe the weak scattering signals from an organic film allows us to ask much more detailed questions about the relationship between film structure and its properties. Since intermediate range order can be affected by processing variables such as temperature, concentration, viscosity etc., an understanding of the interplay of all of these phenomena could provide most valuable clues for deliberately engineering low-cost, high-performance devices.

3. What has motivated you to conduct this work?
We were motivated by a desire to understand, at the most fundamental level, the aspects that control the performance of OLEDs. This research group involved close collaborations among chemists, materials scientists and physicists and by combining expertise in all of these diverse areas we have been able to significantly advance our understanding. The hope is that this will, in turn, allow us to deliberately design low cost, high performance materials for

OLEDs as well as other applications.

4. Where do you see this work developing in the future?
Our results have provided a great deal of insight and detailed understanding of the local structure in amorphous film and how it depends on processing variables. The fact that these can be correlated with device performance parameters such as electric transport, quantum efficiency and lifetime means that we can develop the knowledge base necessary for the deliberate design of easy-to-manufacture, low-cost, high-performance, and long-lifetime devices. We are also trying to refine our analysis further to determine what additional information we may be able to derive. For example: is there a correlation of the average domain size and the transport rates in the film? How do structural changes that occur in the film after exposure to moisture affect device performance?

5. Are there any particular challenges facing future research in this area?
We are still at an early stage, in that we only have a limited number of examples. However, we are encouraged by the fact that we can ascertain the effects, on the intermediate range order, of systematic changes in molecular structure (via synthesis) as well as processing variables as mentioned above. It will also be interesting to study whether our observations apply to other families of materials. Although this will require a great deal of effort, as well as ready and extended access to synchrotron facilities, we are greatly encouraged by the prospects and the promise.

Héctor Abruña

Professor Abruña, the Emile M. Chamot Professor of Chemistry, completed his graduate studies with Royce W. Murray and Thomas J. Meyer at the University of North Carolina at Chapel Hill in 1980, and was a postdoctoral research associate with Allen J. Bard at the University of Texas at Austin. After a brief stay at the University of Puerto Rico, he came to Cornell in 1983. Professor Abruña is the recipient of a Presidential Young Investigator Award, an Alfred P. Sloan Foundation Research Fellowship, a John S. Guggenheim Fellowship, the Tajima Prize of the International Society of Electrochemistry, a J. W. Fulbright Senior Research Fellowship, an Iberdrola Fellowship, and a Fellow of the American Association for the Advancement of Science. Professor Abruña has been serving as the Chair of his Department since 2004.

Observation of intermediate-range order in a nominally amorphous molecular semiconductor film
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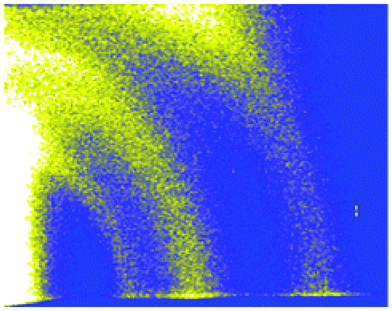

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