MORPHOLOGY OF THIN-FILMS OF POLYFLUORENE:FULLERENE BLENDS

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Our research focuses on **morphological issues** in thin films spin-coated from blends of conjugated polymers, molecules and/or nanoparticles, and on their influence on the performance of solar cells. We characterize the film topography and the in-depth organization of the blend components and aim at achieving control over the film morphology by 1) choice of solvent and spin-coating conditions, 2) control of the surface energy of the substrate and use of modified surfaces and interfaces, and 3) use of tailor-made molecules with specific properties that promote vertical versus lateral structures.

Blends of specially designed low-bandgap polyfluorenes and fullerene derivatives are used in our recent work, directed towards their application in photovoltaic devices. The polymers are designed and synthesized in the group of prof. Mats Andersson, Chalmers University of Technology in Gothenburg, Sweden. The surface topography of the spin-coated thin films is investigated by Atomic Force Microscopy (AFM), using mainly tapping mode. In-depth probing of the composition is performed, through dynamic Secondary Ion Mass Spectrometry (dSIMS), in collaboration with Dr Andrzej Bernasik of AGH – University of Science and Technology and prof. A. Budkowski at the Institute of Physics of the Jagiellonian University, both in Krakow, Poland.

We have found that under specific conditions the thin films spontaneously form layered structures – self-stratification. The driving force for the vertical composition waves is identified as surface-directed spinodal decomposition, assisted by the differences in surface energy between the free surface and the substrate. In the case of weak polymer-fullerene repulsion, the formation of homogenous or stratified compositional profiles is promoted. The formation of lateral structures is favoured by strong polymer-fullerene repulsion. Since the solubility of the fullerene-derivative, PCBM, is limited, the solvent evaporation rate will also play an important role in the film formation, as the kinetics of reaching the 2-phase region compete with the kinetics of PCBM nucleation. The mechanisms leading to these results can be rationalized with thermodynamical and kinetic models of nucleation and phase separation.[1, 2]

Preliminary studies show that self-stratified thin-films improve the solar cell performance, which is not expected within the present model for bulk heterojunction solar cells.[3] We plan to continue the work by extending the morphology studies with the fabrication and electro-optical characterization of polymer solar cells. Hence, we hope to contribute to a better understanding of the morphology-performance relationships in these devices, and to the development of more efficient and more stable polymer-based photovoltaic cells.

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[1] Björström, C.M. et al *Multilayer formation in spin-coated thin films of low-bandgap polyfluorene:PCBM blends* J. Phys.:Condens. Matter 17 (2005) L529-L534;
[2] Nilsson, S. et al *Morphology and phase segregation of spin-casted films of polyfluorene/PCBM blends* Macromol. 40 (2007) 8291-8301;
[3] Björström Svanström, C.M. et al *Device performance of APFO-3/PCBM solar cells with controlled morphology* manuscript.