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Progress in organic solar cells based on advanced neutron scattering methods

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Polymer-based organic solar cells receive a growing interest and achieve a substantial progress concerning device efficiency and lifetime during the last years. Moreover, the potential low fabrication costs, fast energy payback times and the use of lightweight materials make them very appealing. In terms of champion device efficiency, values above the 18% limit were reported recently. Mainly combinations of novel low bandgap polymers and non-fullerene acceptor materials have boosted the device efficiencies. Therefore, polymer-based organic solar cells are addressed in many research groups with a very high level of attention. However, basic understanding is still very limited due to the complexity of the systems. Typically, polymer-based organic solar cells have an active layer made out of a mixture of a positive charge carrier conducting polymer and a small molecule electron acceptor material. Light is absorbed in both components. Excitons are created and split into free charge carriers in case an interface between both components is reached by the exciton within its lifetime. Thus, the morphology of the active layer of an organic solar cell has a significant influence on the final device performance. To enable a high interfacial area between the components, so-called bulk heterojunction (BHJ) geometry is realized in a self-assembly process of the materials. This bulk heterojunction geometry is optimized for exciton splitting and charge carrier transport.
Using advanced neutron scattering techniques such as grazing incidence small angle neutron scattering (GISANS) enables to probe the morphology of the active layers from the molecular to the mesoscopic scale. Typically, contrast conditions are favorable as compared with x-ray scattering and allow for the detection of the intermixed phase between donor and acceptor molecules. As a result, a structure function-relationship can be established, which provides insights into fundamentals of organic solar cells.

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