Counting the winding interface in bulk hetero-junctions of organic solar cells

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The energy efficiency of organic photovoltaics (OPV) has been improved incrementally to reach double digits, due largely to the synthesis of new chemicals. Despite the development, a considerable gap still exists when compared with silicon based solar cells. A major causes of such a gap is the much shorter exciton diffusion length within OPVs, which cannot be easily overcome by the synthesis of new chemicals, therefore the “effective volume” is much reduced. This led to the development of Bulk Hetero-Junctions (BHJ), to increase the junction areas between electronic donors and acceptors by an inter-penetrating interface, so that excitons are never too far away from the junction. This is similar to what has been done in dye-sensitized solar cells (DSSC), where the energy efficiency was increased from 0.1% to over 10%, using nano-porous TiO2 to enhance the interfacial areas up to several hundred times, and in proton exchange membrane fuel cells (PEMFC), where a nano-structured gas diffusion layer was introduced to enlarge the exchange current by 300+ times. However, the BHJs were found to improve the energy efficiency by merely 1-3 times from the bi-layer OPVs, much less than that achieved by DSSCs and PEMFCs. In the absence of junction details, it becomes a critical question, whether a BHJ really enlarges the interfacial area to our expectation. In this talk, we will show that it is possible to count directly the interfacial areas of a BHJ. The result indicates the BHJs today have indeed failed to deliver the desirable interfaces. It also implies that, the problem of low energy efficiency in OPVs becomes morphological in nature.