Is efficiency of organic solar cells limited by their size?

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Serious progress has been achieved in improvement of the photovoltaic (PV) performance of fullerene/polymer solar cells with bulk heterojunction (BHJ) over the last decade: certified efficiencies beyond 8 % have been reported.

Efficient charge generation in BHJ requires that the donor and acceptor materials form an interpenetrating and continuous networks, "phase separated" on the scale of the exciton diffusion length: ≤ 10 nm.

It is widely accepted, however, that BHJ PV performance can be limited by the cell area. All of the record efficiencies were reported for ultra-small BHJ cells but no systematic experimental attention has been paid to the influence of the area of the cells on their performance.

We report the effects of sunlight intensity on the key photovoltaic parameters of OPV with various areas (1 cm^2, 0.25cm^2, 0.04cm^2). Sunlight collected and concentrated outdoors was focused into an optical fiber and delivered onto the glass| ITO|ZnO|P3HT:PCBM|PEDOT:PSS|Ag BHJ-cell. Our results show superiority of small cells for Jsc, Voc, FF and efficiency in all intensity regimes. These results could not be explained solely by conventional lumped series resistance dissipation. We suggest that the distributed nature of the ITO resistance and its effect on the voltage dependence of photocurrent (incomplete exciton separation) is the key to understanding size limitation of OPV efficiency. This limitation can be fundamental for all kind of excitonic cells employing front ITO (or similar) electrode in which current flows parallel to the cell surface.