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Architectures for enhanced exciton collection in organic photovoltaic cells

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Organic semiconductors have received considerable attention for application in a variety of optoelectronic systems including light-emitting devices, lasers, and photovoltaic cells. Due to their compatibility with lightweight flexible substrates and high throughput processing techniques, organic photovoltaic cells (OPVs) represent an intriguing renewable energy option. In these materials, photogenerated excitons must be dissociated in order to generate a photocurrent. Exciton dissociation is typically realized using a donor-acceptor (D-A) heterojunction, where the energy level offset exceeds the exciton binding energy. Mobile excitons diffuse to the D-A heterojunction and are dissociated into their component charge carriers. In most organic materials, the exciton diffusion length is much shorter than the optical absorption length. Consequently, not all of the photogenerated excitons reach the D-A interface, limiting cell efficiency. For small molecule active materials, routes around this bottleneck have centered on the use of mixed D-A film morphologies to increase the area of the dissociating interface. This work instead focuses on the use of OPVs with continuously graded film composition and morphology as a means to simultaneously optimize the exciton diffusion and charge collection efficiencies. In these graded heterojunction OPVs, the power conversion efficiency is noted to exceed that of comparable devices containing a planar or mixed heterojunction. Overall, this approach provides the ability to tune the exciton diffusion and charge collection efficiencies based on the composition profile, permitting greater control over device performance.