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Optimal designs of plasmonic organic photovoltaics

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Incorporation of plasmonic nanoparticles inside optimized organic solar cells is a promising technique for increasing the optical thickness of the photovoltaic absorber layer while keeping the physical thickness fixed. This can be achieved with either, or both, the effects of near-field focusing and far-field scattering of the plasmonic resonances of noble metal nanoparticles. Despite several efforts in literature to incorporate plasmonic enhancers in OPVs, the overall benefits in performance enhancement remain limited and contradicted. This occurs due to the trade-offs between the various parameters that affect the utility of metallic nanoparticles, such as nanoparticle dispersion and device geometry. In this work a full evaluation and optimization of all parameters in MNPs implementation (metal, size, position and periodicity of NPs, as well as device layer thicknesses) is conducted. The different phase spaces of plasmonic enhancement mechanisms are found (i.e. of near-field focusing and far-field scattering), and interesting interplays with the device layer architecture are revealed. These interplays are the main reason for contradictory results and predictions found in the literature. Being now able to simultaneously optimize device architecture and plasmonic nanoparticle dispersion, more than 20% photocurrent enhancement can be achieved for the highly efficient low band-gap polymer blend PCDTBT:PCBM.