Plasmon-Polaron Coupling in Conjugated Polymers on Infrared Metamaterials

Plasmonic nanostructures that strongly enhance local electric fields are widely considered to improve the efficiency of thin film polymer photodetectors and photovoltaics, where absorption and charge photogeneration are limited by the active layer thickness (~100-200 nm).

Compared to conventional inorganic semiconductors, conjugated polymer photophysics is further complicated by strong electron-electron interactions, which often result in the photogeneration of strongly bound electron-hole pair (excitons) and the formation of charge carriers coupled to the lattice (polarons). Since excitons are neutral species, the density of mobile charged polarons generated either directly or indirectly (e.g. by dissociation of excitons) upon photoexcitation is overall responsible for device photocurrent. While common approaches for plasmonic enhancement of polymer photocurrent rely on absorption enhancement by nanostructures resonant with excitonic interband transitions, in this thesis work we propose and demonstrate a completely different approach based on the resonant coupling of the polymer photoinduced polaron states to properly designed infrared (IR) metamaterials.