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Tunable Surface Plasmons for Solar Energy Harvesting

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ABSTRACT

Recently, surface plasmons have been extensively studied to enhance the light absorption of the solar cells. The surface plasmons are a result of optically induced oscillations of the free electrons, which generate a plasmonic near-field that can increase the absorption and/or scattering of light. The role of the surface plasmons in photon-electron conversion of dye sensitized solar cells (DSSCs) was explored by bare metal nanoparticles and surface coated metal nanoparticles. While the localized surface plasmons of metal nanoparticles successfully improved the photocurrent, their plasmonic frequency is pre-determined by the type of metals and less influenced by the size of the nanoparticles. Therefore, the metal nanoparticles may have difficulty in matching the frequency of the surface plasmons with the dye absorption spectrum, which depend on the unique molecular structure of dyes in DSSCs.

In this presentation, I will report that the incorporation of plasmonic particles consisting of metallic nanoshell and dielectric core into TiO_2 mesoporous photoelectrode enlarges the optical cross-section of dye sensitizers coated onto the photoelectrode and increase the energy conversion efficiency of DSSCs. The size of the dielectric core is controlled to tune the absorption and scattering peaks of the core-shell particles. This reconfiguration of the core-shell particle shape is expected to match the surface plasmon wavelength with the absorption spectrum of different dye materials. *J-V* curve and incident photon to current efficiency (IPCE) spectra of DSSCs employing N719 dye. They clearly indicate that the addition of the plasmonic particles enhances the energy conversion efficiency of DSSCs, though the amount of adsorbed dye molecules is decreased. For example, core-shell particles with the radius of 470 nm increase short circuit current (J_{sc}) by about 10%. The enhanced photon-electron conversion is attributed to localized surface plasmons of the core-shell particles, which increase the absorption and scattering of the incoming light in the photoelectrode. We also show that the extinction spectra of the photoelectrode can be effectively controlled by changing the geometric factor of the plasmonic particles. This tuning capability allows us to design the surface plasmons of the core-shell particles to maximize the absorption of the dye molecules with different optical absorption spectrum for dye sensitized solar cells.
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