

PLASMONIC ORGANIC ELECTRONIC DEVICES

Feng Liu¹ and Jean-Michel Nunzi^{1,2}

¹*Department of Chemistry, Queen's University, Kingston, ON*

²*Department of Physics, Queen's University, Kingston, ON
nunzjm@queensu.ca*

Surface plasmons are known as collective oscillations of the conduction electrons at a metallic interface. The phenomenon has been extensively studied in the fields of surface enhanced Raman spectroscopy, metal enhanced fluorescence, and non-linear optics.¹⁻² However, only limited research has been dedicated to its application in organic light emitting diode (OLED). Here we have fabricated a plasmonic OLED by incorporating silica coated silver nanoparticles (NPs) into the emitting layer of a phosphorescent organic light emitting diode (PHOLED), as shown in the schematic diagram Fig. 1. As a result, the luminescence efficiency of the PHOLED is significantly improved under low charge carrier injection level due to surface plasmon enhanced exciton formation probability. In contrast, the incorporation of uncoated bare silver NPs greatly suppresses luminescence of the PHOLED due to metal NPs induced luminescence quenching. A silica shell with thickness 13 nm or above coated on Ag NPs surface can avoid the luminescence quenching of the emitting molecules caused by Ag NPs.

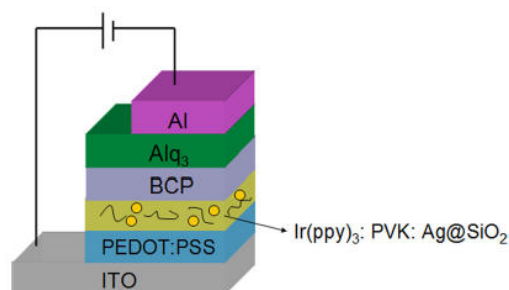


Fig. 1. Configuration of PHOLED doped with silica coated Ag NPs

So far metal nanoparticles (NPs) have been used in thin film silicon solar cell research successfully as the substitute of traditional inverted pyramid surface texture for light trapping. However, the application of metal NPs in organic solar cell research is not as successful as that in silicon solar cell. Although many works have been dedicated to organic solar cells incorporating NPs, none explicitly isolates the optical function of NP from its electronic function in organic solar cells due to the multiple roles played.

We designed a polymer solar cell with configuration shown in Fig. 2 from which we can investigate solely the optical functions of metal NPs in the solar cell. The incorporation of NPs underneath the active layer results in degraded performance due to massive light loss caused by Ag NPs scattering and absorption. In contrast, the incorporation of Ag NPs above active layers can harvest more sun light due to the fact that the surface plasmon of Ag NPs enhances the extinction coefficient of the active polymer layer and the back-scattering from Ag NPs improves the optical absorption path length in the active layer, thus solar cell power conversion efficiency (PCE) is improved. However, a direct contact of Ag NPs with active polymer results in exciton quenching, which compromises its enhancement effect on PCE. The best position to incorporate Ag NPs into the solar cell appears to be above the active layer, with a spacer layer, which is PEDOT in our prototype device.

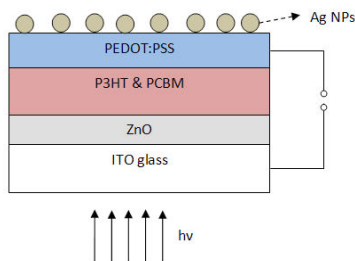


Fig. 2. Schematic diagram of inverted plasmonic solar cell.

References

1. F. Liu, G. Aldea, and J. M. Nunzi, *J. Lumin.* **130**, 56 (2010).
2. J. M. Nunzi and D. Ricard, *Appl. Phys. B* **35**, 209 (1984).