Enhancement of infrared optical response of organic polymers in hybrid nanostructures

Justyna Grzelak[1,3], Aneta Prymaczek[1], Marcin Nyk[2], Maciej Ćwierzona[1], Dawid Piątkowski[1] and Sebastian Maćkowski[1]

[1] Institute of Physics, Nicolaus Copernicus University, Torun, Poland
[2] Institute of Physical and Theoretical Chemistry, Wroclaw University of Technology, Wroclaw, Poland
Email: justynag@fizyka.umk.pl

Up-converting nanomaterials are promising candidates for sensitizing organic solar cells to infrared radiation [1,2]. This however requires developing conditions for efficient energy transfer between the nanocrystals and polymers.

In this work, we describe several strategies to enhance the optical response of conductive polymers to the infrared radiation, for possible application in organic solar cells [3]. Our hybrid nanostructures were composed three types of nanomaterials: conductive polymers with different optical characteristics (absorption/emission), which were energy acceptors; up-converting $NaYF_4$ nanocrystals doped with Er^{3+} and Yb^{3+} ions, which were energy donors; and plasmonically active gold nanoparticles or single silver nanowires. The plasmonic nanomaterials were applied to modify the optical properties of fluorophores placed in their vicinity.

In experiments we used confocal fluorescence microscopy to investigate the energy transfer efficiency from single up-converting nanocrystals to polymers exhibiting different optical properties. The efficient and spectrally – dependent energy transfer from single up-converting nanocrystals to P3HT polymer was observed [4]. For F8BT and PFO polymers we found that reabsorption plays the dominant role in determining the spectral properties of such hybrid nanostructures. It was also observed that the efficiency of the energy transfer depends on the distance between single up-converting nanocrystals and P3HT polymer. Including the plasmonic excitations associated with metallic nanoparticles resulted in further improvement of the energy transfer from the up-converting nanocrystals to the polymers.

Overall, the results prove that it is possible to sensitize conductive polymers to infrared radiation, and thus to allow for more efficient utilization of this part of solar radiation in organic solar cells.

This work was supported by projects 2017/26/E/ST3/00209, 2017/27/B/ST3/02457 and 2016/21/B/ST3/02276 from the National Science Center.

REFERNCES

[1] N. Hartman, *ACS Nano* **7**, 11 (2013) pp. 10257–10262
[2] D. Piątkowski, *Nanoscale*, **7**, 4 (2015), pp. 1479–1484
[3] J. Chappel, *Nature Materials **2*** (2003), pp. 616-621
[4] J. Grzelak, Appl. Phys. Lett. **105** (2015), pp. 163114