Energy-saving Colloidal Quantum Dots Composites for Short-wave Infrared Photodetector

Mu-Huai Fang#

Research Center for Applied Sciences, Academia Sinica, Taipei 11529, Taiwan

Short-wave infrared (SWIR) quantum dots (QDs) are one of the emerging nanomaterials and have drawn immense attention in the field of photodetector. It is, however, still challenging to resolve the voids between the QDs after surface modification, impeding the conduction of the photoelectrons and hindering the practical application of quantum-dot-based photodetectors. Besides, the chemical stability of the QDs after surface modification still needs to be promoted. Here, we synthesize the QDs in which the characteristic absorption peak can be tuned in 900–1700 nm. To achieve the goals above, the composites that QDs hybrid with the metal-organic framework (MOF) and halide-based double perovskite (DP) are demonstrated.[1] In QD@MOF, the particle stacking and preferred orientation of the thin film are characterized by two-dimensional grazing-incidence small- and wide-angle X-ray scattering (GISAXS/GIWAXS). Besides, the chemical bonding between QD and MOF is proved by X-ray absorption near-edge structure spectra. The QD@MOF is applied to graphene field-effect transistors (FETs) to evaluate their potential for practical application. The responsivity and detectivity of the QD@MOF device are 301 A/W and 1.49×10^{10} cm $Hz^{1/2}$ W^{-1}, respectively. The chemical stability is significantly enhanced compared to the non-hybrid one. By contrast, in the QD@DP, the QD is proved to be embedded into the structure of the DP. The responsivity and detectivity of QD@DP graphene FET are 15000 A/W and 1.31×10^{12} cm $Hz^{1/2}$ W^{-1}, respectively, significantly promoted compared to the non-hybrid device. This research provides insight into developing energy-saving QD-based SWIR photodetectors.

[1] Huang, P.-Y.; Zhang, Y.-Y.; Tsai, P.-C.; Chung, R.-J.; Tsai, Y.-T.; Leung, M.-K.; Lin, S.-Y.; Fang, M.-H. (2023) Adv. Opt. Mater., DOI: 10.1002/adom.202302062.

corresponding author: fangmuhuai@gate.sinica.edu.tw