

Photocurrent of arrayed CdSe nanoparticles on Graphene by mesoporous silica templates

Yong-Tae Kim, Young-Seon Ko, Byung Hee Hong*, and Young-Uk Kwon*

[*] Prof. B. H. Hong, Prof. Y. -U. Kwon

Department of Chemistry, BK-21 School of Chemical Materials Science
SKKU Advanced Institute of Nanotechnology, Sungkyunkwon University, Swon, Korea
Y.-S. Ko, Y.-T. Kim

Department of Chemistry, BK-21 School of Chemical Materials Science,
Sungkyunkwon University, Swon, Korea
tanatos@skku.edu

Semiconductor quantum dots (QDs) of group II–VI compounds have been one of the most prominent research topic in the past two decades. QDs show great promises for uses in various applications, such as photovoltaic devices, solar cells and organic/inorganic light emitting devices because II–VI QDs have relatively small band gaps and thus are capable of harvesting photons in the visible and infrared regions. In photon harvesting devices, one of the important aspects to realize is fast electron transfer to the substrates such as indium tin oxide (ITO), fluorine-doped SnO₂ transparent conducting oxide (FTO), and carbon support materials. However, almost all of the researches show problems of inefficient electron transfer. One of the possible reasons for this problem arises from the interface between QDs and the substrate. In this regard the interface between QDs and substrate is a very important factor in improving the solar cells efficiency [1-3].

Recently, hybrid materials based of semiconductor QDs and graphene have motivated active optoelectronic devices studies. Graphene has several unique electronic properties such as high carrier mobility, high transparency, and enhance charge transfer. Therefore, this line of researches may lead to multifunctional materials or even materials with completely new properties. However, at present, the study of QDs/graphene hybrid materials is very limited. Xiumei Geng et al. reported that the flexible and transparent optoelectronic films fabricated from chemically converted graphene (CCG) and QD composites showed improved photosensitivity with the loading of QDs increasing. However, due to the indirect contact between CCG and CdSe QDs capped with Pyridine, the transfer efficiency of the photoinduced carriers is still limited. Probably, it is because of the difficulty in forming junctions between QDs and graphene [4-6].

In our previous work [7], we synthesized CdSe QDs arrays on the graphene basal plane by using electrochemical synthesis method and a mesoporous silica thin film template. This approach produced 8 nm–sized CdSe QDs ordered into a hexagonal array on graphene. The electron diffraction (ED) pattern taken from the top of the graphene plane shows that the (001) planes of the hexagonal CdSe QDs are missing. This suggests that the CdSe QDs are grown epitaxially to the graphene layer, which, in turn, indicate that the interface between the CdSe QDs and the graphene surface has some chemical interaction, desirable for fast electron transfer. In order to prove this possibility and also to develop photon harvesting devices based on our CdSe QDs/graphene hybrid materials, we investigated its photocurrent properties.

References

- [1] C. B. Murray, D. J. Norris, and M. G. Bawendi, *J. Am. Chem. Soc.*, **115** (1993), 8706.
- [2] A. Kongkanand, K. Tvrđy, K. Takechi, M. K. Kuno, and P. V. Kamat, *J. Am. Chem. Soc.*, **130** (2008), 4007.
- [3] Y. Lin, K. Zhang, W. Chen, Y. Liu, Z. Geng, J. Zeng, N. Pan, L. Yan, X. Wang, and J. G. Hou, *ACS Nano* **4** (2010), 3033.
- [4] K. S. Kim, Y. Zhao, H. Jang, S. Y. Lee, J. M. Kim, K. S. Kim, J.-H. Ahn, P. Kim, J.-Y. Choi, B. H. Hong, *Nature* **457** (2009), 706.
- [5] X. Geng, L. Niu, Z. Xing, R. Song, G. Liu, M. Sun, G. Cheng, H. Zhong, Z. Liu, Z. Zhang, L. Sun, H. Xu, L. Lu, and L. Liu, *Adv. Mater.* **22** (2010), 638.
- [6] Z. Chen, S. Berciaud, C. Nuckolls, T. F. Heinz, and L. E. Brus, *ACS Nano* **4** (2010), 2964.
- [7] Y. T. Kim, J. H. Han, B. H. Hong, and Y. U. Kwon, *Adv. Mater.* **22** (2010), 515.

Figures

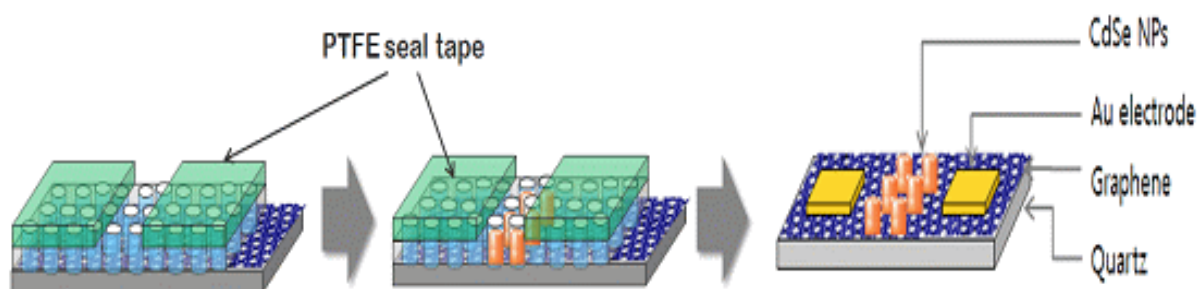


Figure 1. Scheme of the photo-device by CdSe QDs arrays on graphene sheet.

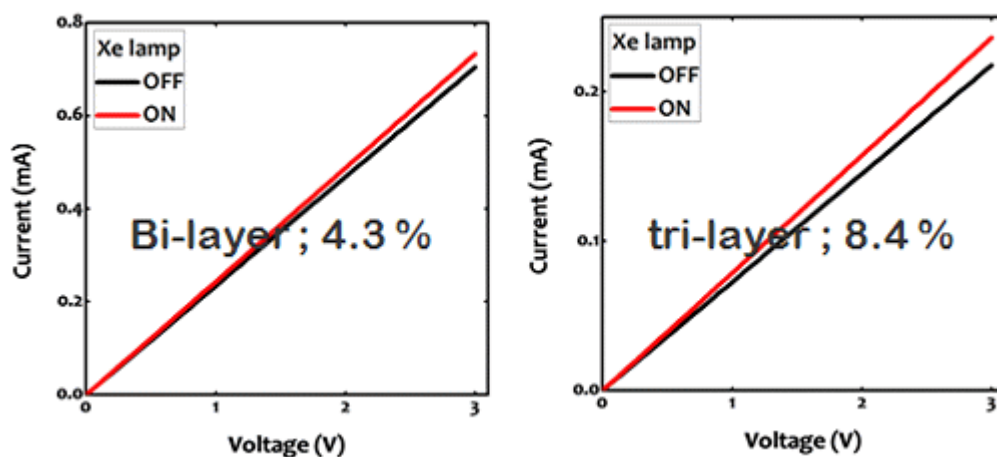


Figure 2. Current-voltage characteristics of the CdSe QDs (240s)/graphene/quartz with and without the irradiation under a 100 mW/cm^2 light illumination condition. The amount of electrodeposited CdSe QDs on graphene is the same each other, but the number of layers of graphene is controlled as follows: bi-layer and tri-layer graphene.