Electron Transport in Iodide-Capped PbTe@PbS Core@Shell Nanocrystals

Retno Miranti[1], ○Satria Z. Bisri[1,2], Maria Ibáñez[3,4], Maksym V. Kovalenko[4], Nobuhiro Matsushita[1], and Yoshihiro Iwasa[2,5]

Tokyo Inst. of Tech.[1], RIKEN-CEMS[2], IST Austria[3], ETH Zurich[4], The Univ. of Tokyo, Japan[5]

Email: *satria.bisri@riken.jp*

Research in colloidal semiconductor nanocrystals (NCs) have been progressed tremendously, mostly because of their exceptional electronic and optical properties. This material assemblies have attracted significant attention due to their size-dependent quantum confinement properties. The ability to control the charge carrier transport in the colloidal QDs assemblies is fundamental for the development of many electronic devices (e.g. solar cells, thermoelectrics, transistor, and photodetectors). These applications require highly controllable electron and hole transport to alter its electronic and optical properties. To achieve n-type, many strategies have been used, such as doping through ligand control, stoichiometry and remote doping. Recently, we demonstrated exclusive electron transport in PbTe@PbS core@shell NCs that drastically suppressed contribution of holes to the overall transport distinct to the ambipolar characteristics demonstrated by many narrow bandgap NCs, while simultaneously electron dope the PbTe core.[1] Nevertheless, n-type transport-instability has so far remained a challenge for narrow bandgap Pb-chalcogenide NCs, including this PbTe@PbS core@shell NCs. Here we show enhancement of electron transport and stability in the assemblies of the core@shell NCs using of iodide as the passivating ligand. We compared the electron transport in the field-effect transistors (FETs) of the core@shell NCs between the one used iodide as the replacement ligand and the other that used 1,2-ethanedithiol as the ligand. Using iodide ligand, in addition to the exclusive electron transport behavior, the FET showed higher electron conductivity. This higher electron conductivity is due to the contribution of iodide that act as addition electron dopant into the system. In combination with the shelling, the addition sheet electron in the FET can be as much as 6.6×10^{12} electron/cm^2. In contrast with the use of organic ligand, where the device performance degrades quickly, the use of iodide ligand made the shelf life of the device performance significantly longer, in particular the electron transport characteristics. The advantage of the exclusive electron transport with stable device performance makes these iodide-capped core@shell PbTe@PbS NCs suitable for practical electronic device applications.

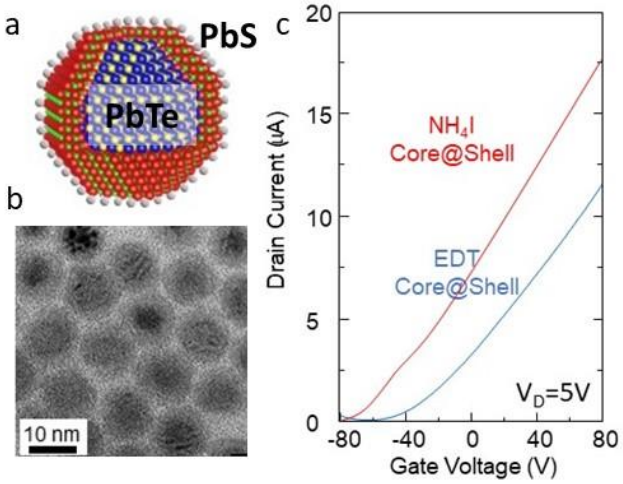

Fig. 1. (a) Schematic of PbTe@PbS core@shell nanocrystals (NC) capped by iodide. **(b)** Transmission electron micrograph (TEM) of the core@shell NC after iodide ligand exchange. **(c)** The comparison of the I_D-V_G transfer characteristics of the core@shell NC FETs using iodide and 1,2 ethanedithiol (EDT) capping.

Ref: [1] R. Miranti, D. Shin, R. D. Septianto, M. Ibáñez, M. V. Kovalenko, N. Matsushita, Y. Iwasa, S.Z. Bisri, *ACS Nano* 14, 3242-3250 (2020).