Strategy to Control Electron Transport in Transistor of Type II Core@Shell Lead Chalcogenide Colloidal Quantum Dot Assemblies

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Colloidal quantum dots (QDs) assemblies have attracted significant attention due to their size-dependent quantum confinement properties. The ability to control over charge carrier transport in the colloidal QDs assemblies is fundamental for the development of many electronic devices (e.g. solar cells, thermoelectrics, and photodetectors). In this report, we demonstrate strategies to control hole and electron transport in QDs assemblies. Firstly, shelling lead chalcogenide QDs with different lead chalcogenide layer was performed to form a type II core@shell QDs. The assemblies of these core@shell QDs are crosslinked by short organic molecules that replaced the native insulating oleic acid ligand. The electronic transport measurement of the core@shell QDs solid show only an exclusive n-type transport which is different to what typically observed in their corresponding core-only QDs assemblies that exhibit ambipolar transport.[1] Secondly, we prepared core@shell QDs assemblies crosslinked by halide salt to replace the native oleic acid ligand. The electronic transport measurement shows strong n-type characteristic with threshold voltage for electron accumulations shifted as much as -115 V. By combining shelling of QDs and utilization of halide salts as ligand we found an additional electron doping density of 1.13×10^{13} cm^{-2}. We found that the transistor device of these core@shell QDs assembly shows very good stability. These exclusive n-type transport arises simply due to the mismatch of the core QD bandgap and wider bandgap of the shelling compound. In this case, the hole transport is suppressed by hole-localization in the core valence level. Furthermore, the halide salt promotes enhancement of electron transport by passivating the QDs surface as well as providing electron doping. The exclusive n-type transport makes these core@shell QDs capped with halide ligand more suitable for applications where ambipolar characteristics should be strongly suppressed to enhance their performance, such as photodetectors, thermoelectric, as well as selective electron transporting layer in solar cells.

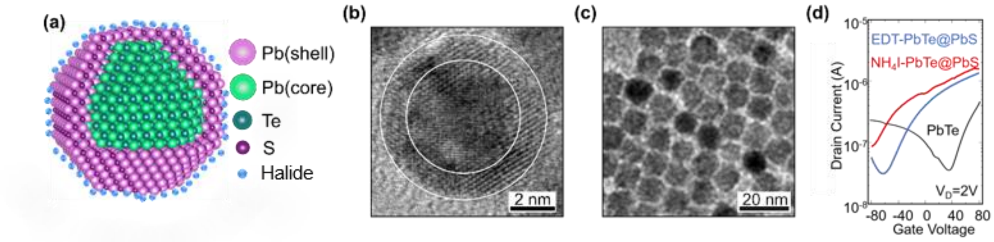

Fig. 1. (a) Schematic and (b) HRTEM image of core@shell QD, (c) TEM micrograph and (d) the corresponding transport characteristic transistor of core@shell QD assemblies.

(1) R. Miranti, D. Shin, R. D. Septianto, M. Ibáñez, M. V. Kovalenko, N. Matsushita, Y. Iwasa, S.Z. Bisri, *Under Revision* (2020)

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