Effect of Core Size and Shell Thickness on Charge Carrier Transport in Core@Shell Lead Chalcogenide Colloidal Nanocrystals

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Colloidal semiconductor nanocrystals (NCs) have been studied for the next-generation electronic and optoelectronic technology due to their size-dependent bandgap tunability and solution processability. Core@shell NCs have attracted significant attention especially due to their exceptional optical characteristic. It benefits in reduced Auger recombination, suppressed blinking, and enhanced carrier multiplication. The influence of the shell on their charge carrier transport has become an important subject of study. In our previous report, we have successfully demonstrated the role of shelling a PbTe NC core with PbS which made them exclusively electron-transporting. The energy level offset in the so-called quasi-type-II NC made the hole strongly localized within the NC.[1,2] However, important questions on how the core size and shell thickness influence the charge carrier transports of their assembly remain unanswered. In this work, the effect of core size and shell thickness on the charge carrier transport in the core@shell PbTe@PbS colloidal NCs assembly is studied. The assemblies of these core@shell NCs are crosslinked by short organic molecules that replaced the native insulating oleic acid ligand via liquid/air assembly technique. Properties of these assemblies are measured using both conventional solid gate transistor and electric-double-layer transistor. The electronic transport measurement shows an evolution of transport characteristics as a function of shell thickness and core size. We observe the transport characteristic transforms from n-type to ambipolar for a thicker shell. It suggested that the alignment energy-level of core and shell strongly depends on its core and shell sizes. As the result, core@shell PbTe@PbS may form a type I, type II, and quasi type II by simply altering its core and shell sizes. This various type offers by core@shell PbTe@PbS benefits for wide-range electronic applications.

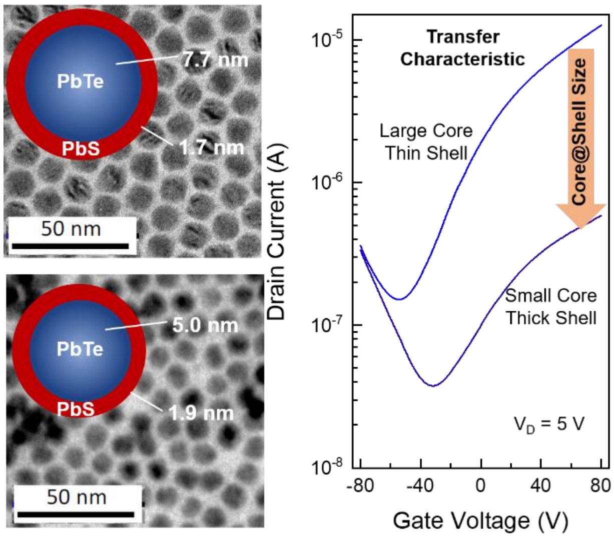

Figure 1. Size dependent I_D-V_G transfer characteristic of Core@Shell PbTe@PbS field-effect transistor

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.

2) R. Miranti, R. D. Septianto, M. Ibáñez, M. V. Kovalenko, N. Matsushita, Y. Iwasa, S.Z. Bisri. APL 117, 173101, 2020.