Ligand effects on PbS Colloidal Quantum Dot Assemblies and Electronic Performances

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Colloidal quantum dots (colloidal QDs) are of remarkable research interest due to their prospects for a wide range of application in low-power-consuming electronics and energy-generating devices, including solar cells[1], photodetectors, thermoelectrics and light-emitting devices. Although the well-developed wet synthesis gives PbS QDs covered with long, insulating ligands as native capping agents (e.g. oleic acid), they can be replaced by short ligands to afford more conductive QD films suitable for device applications. Indeed, ligand exchange can alter various properties of QDs, such as inter-dot distance, crosslinking degree, the energy level of trap states, and doping degree, thereby determining the device performance of QDs.

Here we carefully compared the assembly structure and electronic transport properties of quantum dots with different short chain acids.[2] Firstly, all of the short chain acid ligands here give PbS QDs a p-type doping behavior. Secondly, 2,5-thiophene dicarboxylic acid capped PbS QDs gives the best performance compared with the other short chain acid (Fig.1), which demonstrates the record highest hole mobility. Thirdly, we found that the distance between the QDs does not exactly correspond to the length of the molecules. Therefore, the influence of the molecule type towards the inter-QD distance and the enhancement of hole mobility will be discussed. The demonstration of p-type PbS QD with high hole mobility will be very important for many device applications.

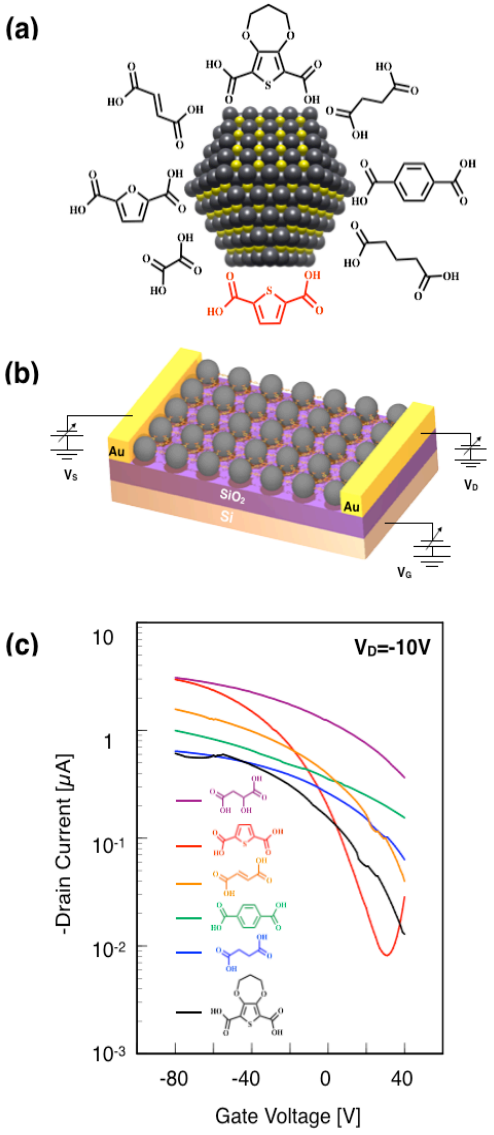

Fig.1 (a) Various molecules that are being used to functionalize and to crosslink PbS colloidal QDs and its corresponding device (b) and I_D-V_G curve (c).

Reference:

(1) Pietryga, Jeffrey M., et al. Chem. Rev. 116.18 (2016);

(2) Liming Liu, et al., to be submitted