A study of efficient charge transfer in PbS colloidal quantum dots solids

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We investigated how changing the ligand on the PbS colloidal quantum dots (CQDs) surface affects the strength of coupling and resulting charge carrier transfer dynamics inside PbS CQDs solids. The ligand-shell plays an important role in determining the distance between CQDs, the transport properties, and superlattice symmetry in solids[1]. Optimal ligands for the synthesis of CQDs are long and dynamically passivate the surface of CQDs. On the other hand, ligands that are best for device performance are short in order to promote inter-dot coupling, and are strongly bound to the CQDs surface to passivated mid-gap defect states[1]. Therefore, it is necessary to exchange ligand from post-synthesis ligands to strongly bound shorter ligands[2]. In our experiments, we conducted a strategy for enhancing charge carrier transfer by exchanging the native, long organic chains to short organic chains and atomic ligands: oleylamine (OLA) ligands, oleic acid (OA) ligands, and Br atomic ligands.

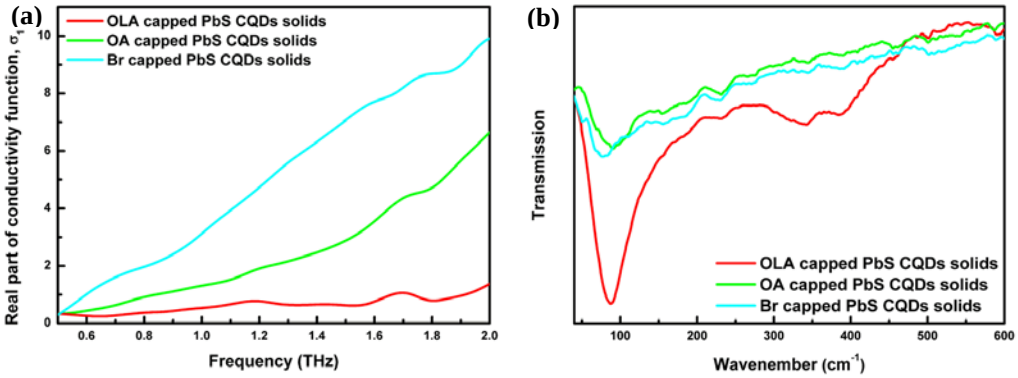

Fig. 1. (a) The real part of complex conductivity function with OLA, OA, and Br capped PbS CQDs solids and (b) the FIR spectrum of PbS CQDs solids with various ligands.

The complex conductivity function σ(ω) was obtained, as shown in Fig. 1 (a). The OLA and OA ligands have a similar chain length (~ 2 nm). However, the conductivity of OLA capped PbS CQDs solids was a flat near zero, whereas OA capped PbS CQDs solids wasn't. That resulted from isolated dot system due to OLA ligands shell having large inter-dot distance, as shown in Fig. 1 (b). Three quantized phonon modes were clearly seen for OLA capped PbS CQDs solids; there was a strong Fröhlich mode in OLA capped PbS CQDs solids and the Fröhlich mode seemed less intense and broadened due to mode splitting[3]. Therefore, the OLA capped PbS CQDs solids can only have an isolated dot system among samples, because the OLA ligands (monodentate) can adsorb onto a whole surface of CQDs. Also, there was a dramatic increase in conductivity of Br capped PbS CQDs solids as a result of the decrease in the inter-dot distance. Finally, we propose a guidance for architects of chemical stretegies for enhancing conductivity of CQDs solids.

Acknowledgment

References

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