Solution-Processed QD Solid by Doctor Blading Based on PbS QD Nanoinks for the Fabrication of Photodetectors at Telecom Wavelengths

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Abstract:

Solution-processed QD solids are emerging as a novel concept for high-performance optoelectronic devices [1]. In this work, doctor blading is proposed for the realization of closed-packed QD solids from a PbS nanoink for the fabrication of photodetectors at telecom wavelengths. The key step of this procedure is the solid-state ligand exchange, which reduces the interparticle distance and increases the carrier mobility in the QD solid [2]. This is accomplished by replacing the original long oleylamine molecules by shorter molecules such as 3-Mercaptopropionic acid, as confirmed by FTIR, TGA and XPS. XPS surface analysis of the QD solid shows a decrease of undesired oxidation products, like $PbSO_3$, as result of an optimized ligand exchange procedure. XPS also reveal the presence of an oxidized shell around the PbS core, mainly composed by $Pb(OH)_2$, that does not affect the structural quality of the PbS core and effectively passivates the QD surface [3]. Finally, the QD solid was tested as active layer for the fabrication of a Schottky NIR photodetector. The device performances are among the most appealing so far reported [2], with a maximum responsivity of 0.26 A/W that corresponds to an internal quantum efficiency higher than 30 % at 1500 nm and detectivity around 10^{11} Jones.

References

[1] M. P. Hansen and D. S. Malchow, Proc. SPIE, vol. 6939, **"Overview of SWIR detectors, cameras, and applications,"** pp. 69390I-1–69390I-11, Mar. 2008.

[2] Ruili Wang, Yuequn Shang, Pongsakorn Kanjanaboos, Wenjia Zhou, Zhijun Ning and Edward H. Sargent, Energy Environ. Sci., vol. 9, **"Colloidal quantum dot ligand engineering for high performance solar cells"** pp. 1130—1143, 2016.

[**3**] G. Konstantatos and E. H. Sargent, Proc. IEEE vol. 9, **Solution-processed quantum dot photodetectors**, pp. 1666-1683, 2009.