

Properties of the CsPbBr₃ Quantum Dots Treated by O₃ Plasma for Integration in the Perovskite Solar Cell

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Abstract : Perovskite quantum dots (PQDs) have the potential to increase the performance of the perovskite solar cells (PSCs). The integration of PQDs into PSCs can extend the absorption range and enhance photon harvesting and device efficiency. In addition, PQDs can stabilize the device structure by passivating surface defects and traps in the perovskite layer and enhance its stability. The integration of PQDs into PSCs is strongly affected by the type of ligands on the surface of PQDs. The ligands affect the charge transport properties of PQDs, as well as the formation of well-defined interfaces and stability of PSCs. In this work, the CsPbBr₃ QDs were synthesized by the conventional hot-injection method using cesium oleate, PbBr₂, and two different ligands, namely oleic acid (OA)@oleylamine (OAm) and didodecyldimethylammonium bromide (DDAB). The STEM confirmed regular shape and relatively monodisperse cubic structure with an average size of about 10-14 nm of the prepared CsPbBr₃ QDs. Further, the photoluminescent (PL) properties of the PQDs/perovskite bilayer with the ligand OA@OAm and DDAB were studied. For this purpose, ITO/PQDs, as well as ITO/PQDs/MAPI perovskite structures, were prepared by spin coating, and the effect of the ligand and oxygen plasma treatment was analysed. The plasma treatment of the PQDs layer could be beneficial for the deposition of the MAPI perovskite layer and the formation of a well-defined PQDs/MAPI interface. The absorption edge in UV-Vis absorption spectra for OA@OAm CsPbBr₃ QDs is placed around 513 nm (the band gap 2.38 eV); for DDAB CsPbBr₃ QDs, it is located at 490 nm (the band gap 2.33 eV). The photoluminescence (PL) spectra of CsPbBr₃ QDs show two peaks located around 514 nm (503 nm) and 718 nm (708 nm) for OA@OAm (DDAB). The peak around 500 nm corresponds to the PL of PQDs, and the peak close to 710 nm belongs to the surface states of PQDs for both types of ligands. These surface states are strongly affected by the O₃ plasma treatment. For PQDs with DDAB ligand, the O₃ exposure (5, 10, 15 s) results in the blue shift of the PQDs peak and a non-monotonous change of the amplitude of the surface states' peak. For OA@OAm ligand, the O₃ exposition did not cause any shift of the PQDs peak, and the intensity of the PL peak related to the surface states is lower by one order of magnitude in comparison with DDAB, being affected by O₃ plasma treatment. The PL results indicate the possibility of tuning the position of the PL maximum by the ligand of the PQDs. Similar behaviour of the PQDs layer was observed for the ITO/QDs/MAPI samples, where an additional strong PL peak at 770 nm coming from the perovskite layer was observed; for the sample with PQDs with DDAB ligands, a small blue shift of the perovskite PL maximum was observed independently of the plasma treatment. These results suggest the possibility of affecting the PL maximum position and the surface states of the PQDs by the combination of a suitable ligand and the O₃ plasma treatment.

Keywords : perovskite quantum dots, photoluminescence, O₃ plasma., perovskite solar cells

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