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Newly Synthesized Silicon Quantum Dot–Polystyrene Nanocomposite Having Thermally Robust Positive Charge Trapping

Mai Xuan Dung, Jin-Kyu Choi, Hyun-Dam Jeong*

Department of Chemistry, Chonnam National University, Gwangju 500-757, Korea

Striving to replace the well known silicon nanocrystals embedded in oxides with solution-processable charge-trapping materials has been debated because of large scale and cost effective demands. Herein, a silicon quantum dot-polystyrene nanocomposite (SiQD-PS NC) was synthesized by post-functionalization of hydrogen-terminated silicon quantum dots (H-SiQDs) with styrene using a thermally induced surface-initiated polymerization approach. The NC contains two miscible components: PS and SiQD@PS, which respectively are polystyrene and polystyrene chains-capped SiQDs. Spin-coated films of the nanocomposite on various substrate were thermally annealed at different temperatures and subsequently used to construct metal-insulator-semiconductor (MIS) devices and thin film field effect transistors (TFTs) having a structure p-S^{++}/SiO_2/NC/pentacene/Au source-drain. C-V curves obtained from the MIS devices exhibit a well-defined counterclockwise hysteresis with negative fat band shifts, which was stable over a wide range of curing temperature (50～250^oC. The positive charge trapping capability of the NC originates from the spherical potential well structure of the SiQD@PS component while the strong chemical bonding between SiQDs and polystyrene chains accounts for the thermal stability of the charge trapping property. The transfer curve of the transistor was controllably shifted to the negative direction by chaining applied gate voltage. Thereby, this newly synthesized and solution processable SiQD-PS nanocomposite is applicable as charge trapping materials for TFT based memory devices.

Keywords: Silicon quantum dots, Polystyrene, Nanocomposite, Charge trapping, OTFTs