Solar cells based on atmospheric plasma synthesis and surface engineered Si-/C-quantum dots.

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Si- and C-nanomaterials with strong quantum confinement and engineered energy bandgap exhibit unique properties used in many fields of applications (e.g. solar cells, biology, optoelectronics). In this contribution, we demonstrate that a confined atmospheric plasma interaction through liquid media is a suitable technique for the synthesis and/or surface treatment of Si- and C-quantum nanomaterials. Two different plasma-liquid sources are applied for synthesis and surface engineering: a femtosecond (fs) laser beam (100 fs) is used to generate a plasma in the liquid; and an atmospheric pressure direct-current (dc) microplasma is generated under ambient air conditions and coupled to the colloid via a counter electrode.

We show that C-quantum dots with sizes less than 5 nm can be synthesized using both plasma sources. The C-quantum dots are formed using molecular precursors and show interesting quantum confined optical properties, and the incorporation of C-quantum dots as the active layer in a solar cell resulted in a high open-circuit voltage of 1.8 V. On the other hand, we show that during plasma processing of Si-quantum dots we can successfully tune the OH surface functionalization. Si-quantum dots functionalized as such can better interact with a host matrix.

We present the study of an organic-inorganic hybrid material based on methylammonium iodo bismuthate $(CH_3NH_3)_3(Bi_2I_9)$ (MABI) thin films. Due to the large proportion of localised excitons, coupled with delocalised excitons from intercluster energy transfer, an anisotropic photoluminescence is observed. The observation of nonlinear photoluminescence properties at excitation energy above twice the bandgap indicates carrier multiplication due to the low-dimensional Bi_2I_9 clusters. We show that the MABI structure can also accommodate plasma surface engineered Si-quantum dots and we observe an enhancement in the short-circuit current when applied in solar cells as an active absorption layer.