COQUASIHYB
COLLOIDAL QUANTUM DOT – SI HYBRID PV STRUCTURES

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Silicon is one of the most well studied and widely used semiconductors for development of photovoltaic cells. However, as an indirect band gap semiconductor it is characterized by low light absorption and low exciton efficiency. The power conversion efficiency of the commercial photovoltaic modules achieved to date does not exceed 15%. To overcome the existing limitations we follow a hybrid approach, which combines different materials for efficient solar absorption and carrier extraction. Such a hybrid photovoltaic device would be a potentially inexpensive scheme for achieving high-efficiency and low-cost solar-cell platforms.

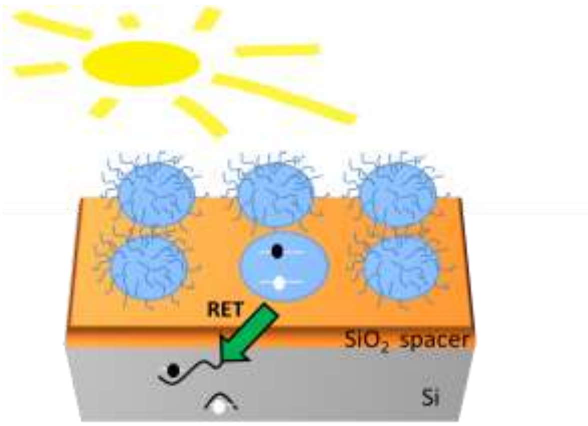

Figure 1: Schematic description of RET mechanism from PbS NCs to bulk silicon substrate

The main objective of this project is to develop and demonstrate a hybrid photovoltaic device, by taking advantage of the optical properties of semiconductor nanocrystals (SNCs) and the mature technology of bulk semiconductors. This device exploits the absorption of solar photons and the creation of excitons from the PbS SNCs to a silicon p-n junction. PbS SNCs exhibit a tunable absorption spectrum, which can be matched to the solar radiation and thus enhance the amount of the collected solar energy. In such devices, SNCs can be used as solar absorbers and their electronic excitation can be transferred from the SNCs to the bulk silicon by means of Resonant Energy Transfer (RET).

We used time resolved measurements for studying the dynamics of PbS NCs and the efficiency of RET from PbS SNCs to bulk silicon. The efficiency of the RET mechanism between the PbS SNCs and silicon is modulated by varying the distance between them. Recent results undoubtedly indicate the occurrence of RET from colloidal SNCs to bulk silicon. Temperature measurements also show that the RET efficiency remains high across a range of temperatures, with a value of 44% at room temperature. Furthermore, we have also fabricated simple prototype devices in order to confirm electrically energy transfer from the PbS SNCs to silicon. Preliminary results show an increase of 12% in photocurrent due to RET at room temperature and are very promising with a view to eventually realizating high efficiency light harvesting devices in a time of ever increasing energy consumption.

Expected final results and their potential impact and use

The results of this project provide compelling experimental evidence that RET is an efficient mechanism in PbS/Si hybrid configurations with reported efficiency of 44% at room temperature. In collaboration with Q-CELLs such hybrid configurations are now being pursued in completed p-i-n fully nanotextured heterostructures. Any improvement reported on such configurations is expected to impact on the efficiency of x-Si PVs.