CdTe and CdTe/CdSe Core/Shell Aqueous Soluble Quantum Dots-Sensitized Solar Cell

Ana B. F. Vitoreti, Brener R. C. Vale, Ellen Raphael, Paulo H. Pereira, Marco A. Schiavon

Grupo de Pesquisa em Química de Materiais–(GPQM), Departamento de Ciências Naturais, Universidade Federal de São João del-Rei, São João del-Rei, MG, Brazil.

The use of quantum dots in solar cells stands out among the several applications due to the growing interest for research of new alternative sources of energy. [1] Experimental methods evolved and they are focused in searching of processes that generate the highest photoluminescence quantum yields, suitable surface properties, and narrow size distributions. [2] In this context QDs synthesis by aqueous colloidal chemistry has been extensively studied. [3] In this work, we have prepared aqueous-soluble CdTe and CdTe/CdSe core/shell for application in solar cells. Core/shell structures are a good strategy to increase the energy conversion efficiency of the solar cell due to efficient charge separation that these systems promote. We have use mercaptosuccinic acid as surface ligand for the QDs, because this ligand has in its structure carboxylate groups, which have fundamental importance for applications in sensitized solar cells, where TiO_2 is used as nanostructured semiconductor. [4,5]

Core/shell quantum dots has improved surface, and therefore reduced defect states. Thus, they have improved optical properties such as increased quantum yield and life-time values in the excited state. [6] Two different protective layers (CdS and ZnS) were applied in quantum dots-sensitized solar cells to allow the study and influence this layers in the parameters of the solar cells. [7]

In the solar cells sensitized by these QDs the performance is different for the CdTe and for the CdTe/CdSe core/shell, because their materials have different charge separation. The protective layers exhibit similar behavior when used with the different QDs. For CdTe, the ZnS protective layer is responsible for reducing recombination losses with the electrolyte, however a equilibrate between passivation and charge transfer must be achieved. For this, the thickness of this layer is important, since when it becomes very thick, the electrolyte is partially prevented from reaching the QDs for their regeneration, causing a decrease in the efficiency of the solar cell, which displayed a reduction of 60% when compared to the uncovered CdTe (Fig. 1). The use of another quantum dot to cover the adsorbed QDs on TiO_2 is another method that reduces the recombination of charges with the electrolyte. By using the CdS, passivation of the surface of the adsorbed QDs occurs allowing the sensitization of the uncovered TiO_2 surface by CdTe. The protective layer of CdS was responsible for a 350% increase in cell efficiency, but cell stability was not suitable as can be seen in Fig.1. The double-layer passivation was then proposed to improve the cell performace. Thus, with one layer (CdS) it is possible to increase the absorption range, and the with the other one (ZnS) we achieved for reducing the losses by recombination, improving the power conversion efficiency and the stability of the cells as well. The double layer improved cell efficiency by 600% when compared to the cell containing only CdTe, and 70% relative to the cell coated with CdS.

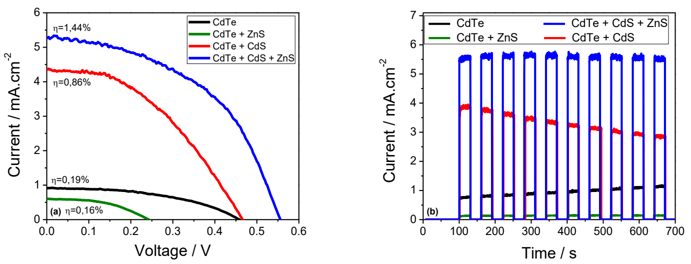

Fig.1: Photovoltaic performance of CdTe solar cells with different protective layers exposed at 1 sun AM1.5 (100 $mWcm^{-2}$).

Each protective layer (CdS or ZnS) has some disadvantages, which were suppressed when both of them were combined together in the same device. The addition of these layers allowed a higher absorption of photons, and reduction of the recombination with the electrolyte, thus improving the photocurrent, efficiency and stability of the solar cells. To explain the charge transfer mechanisms involved in the solar cells prepared we have used the time-resolved photoluminescence technique.

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