N1-011

Fabrication of Schottky Device Using Lead Sulfide Colloidal Quantum Dot

Jun Kwan Kim, Jung Hoon Song, Hye Jin An, Hyekyoung Choi, Sohee Jeong*

Nano-Mechanics Division, Korea Institute of Machinery & Materials (KIMM), Daejeon 305-343, Korea

Lead sulfide (PbS) nanocrystal quantum dots (NQDs) are promising materials for various optoelectronic devices, especially solar cells, because of their tunability of the optical band-gap controlled by adjusting the diameter of NQDs. PbS is a IV-VI semiconductor enabling infrared-absorption and it can be synthesized using solution process methods. A wide choice of the diameter of PbS NQDs is also a benefit to achieve the quantum confinement regime due to its large Bohr exciton radius (20 nm). To exploit these desirable properties, many research groups have intensively studied to apply for the photovoltaic devices.

There are several essential requirements to fabricate the efficient NQDs-based solar cell. First of all, highly confined PbS QDs should be synthesized resulting in a narrow peak with a small full width-half maximum value at the first exciton transition observed in UV-Vis absorbance and photoluminescence spectra. In other words, the size-uniformity of NQDs ought to secure under 5%. Second, PbS NQDs should be assembled carefully in order to enhance the electronic coupling between adjacent NQDs by controlling the inter-QDs distance. Finally, appropriate structure for the photovoltaic device is the key issue to extract the photo-generated carriers from light-absorbing layer in solar cell. In this step, workfunction and Fermi energy difference could be precisely considered for Schottky and hetero junction device, respectively.

In this presentation, we introduce the strategy to obtain high performance solar cell fabricated using PbS NQDs below the size of the Bohr radius. The PbS NQDs with various diameters were synthesized using methods established by Hines with a few modifications. PbS NQDs solids were assembled using layer-by-layer spin-coating method. Subsequent ligand-exchange was carried out using 1,2-ethanedithiol (EDT) to reduce inter-NQDs distance. Finally, Schottky junction solar cells were fabricated on ITO-coated glass and 150 nm-thick Al was deposited on the top of PbS NQDs solids as a top electrode using thermal evaporation technique. To evaluate the solar cell performance, current-voltage (I-V) measurement were performed under AM 1.5G solar spectrum at 1 sun intensity. As a result, we could achieve the power conversion efficiency of 3.33% at Schottky junction solar cell. This result indicates that high performance solar cell is successfully fabricated by optimizing the all steps as mentioned above in this work.

This work was supported by the Global Frontier R&D Program by the Center for Multiscale Energy Systems funded by the National Research Foundation under the Ministry of Education, Science, and Technology, the Industrial Core Technology Development Program funded by the Ministry of Knowledge Economy (No. 10035274).

Keywords: Lead sulfide, Quantum dots, solar cells, Schottky device