行政院原子能委員會
委託研究計畫研究報告

【應用於太陽能轉換之量子點敏化InN/TiO_2奈米粒子薄膜研發】

【Quatum-Dot Enhanced InN/TiO_2 Nanoparticle Films for Solar Energy Conversion Application】

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中文摘要

本計畫是為期三年行政院原子能委員會委託研究計畫之第二年執行結果摘要。本年的主要工作在進行以下目標：利用不同大小的半導體量子點(QD)取代有機染料，改善其不穩定的缺點。在半導體量子點敏化的研究中，選用不同的錮化物及金作為吸收太陽能的敏化物。同時，以 InN 覆蓋量子點與 TiO_2 混合作基板功能的研究也在進行，基板導電的好壞影響太陽能轉換的效率，所以 TiO_2 基板品質的提昇，亦是本年度研究重心之一。

在上述不同角度上的努力，目前太陽能轉換效率已從去年底 nA 左右的光電流增進 30 幾倍，同時，N_3-dye/TiO_2 系統的 AM1.5 光電流偵測已達到 6.8 %的效率。另外，在一系列的量子點-二氧化鈦混合作基板，InN/QD-TiO_2 系統的光電流，亦有大幅增加。目前，最高效率已達到 0.22 %光電效用，未來一年期望效率可高達 3-5 %。

Abstract

With very scarce natural energy resources, Taiwan should invest with high priority in renewal energy research. In this area of scientific endeavor, Taiwan is lagging very far behind Japan, the US and Europe. The Sun is an inexhaustible natural energy source, efficient utilization of solar energy should be one of the most important technological challenges of the 21st century.

In the proposed studies at NCTU, we focus primarily on the development of an economically viable solar energy conversion system for photovoltaic and/or photo-electrochemical water-splitting applications. The low-cost, nontoxic and chemically and thermally stable properties of TiO_2 have resulted in much recent research effort to circumvent its large band gap (3.2 eV or 387 nm) by modifying its surface optical properties for applications in the visible region of the spectrum, specifically for solar energy conversion. The best known technique to enhance its photovoltaic efficiency is Graetzel's method using dyes to improve its photoabsorption cross section and electron transfer dynamics.

The best dye employed by Graetzel and co-workers, $RuL(SCN)_3$, has reached ~10% solar energy conversion efficiency under their best operational conditions. It is comparable to amorphous silicon systems with 9-10% efficiencies and is less than that of polycrystalline silicon devices which have been reported to reach >15% efficiency. It should be noted that both the organic dye/TiO_2 and polycrystalline Si systems are costly and still cannot compete economically with fossil fuels such as oils and natural gases.

In the past year, we have focused on studies of the effects of InN nanoparticle size and of a variety of In-containing semiconductor quantum dots at the interface of InN and TiO_2 on the devices' photocurrents. In addition, we have attempted to improve the quality of the TiO_2 substrate using different sol gel preparation methods as well as mixing TiO_2 with quantum dots of Au, In_2S_3, In_2O_3, among others.

For pure TiO_2 substrates, we have now achieved 6.8% efficiency for the N_3-dye/TiO_2 test device. Overall, we have characterized many samples with AM1.5 simulation and have obtained >0.2% photo-electric conversion efficiency.