Synthesis of $CuInS_2$ Quantum Dots on TiO_2 Porous Films by Solvothermal for Absorption Layer of Solar Cells

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Abstract

Copper indium disulfide ($CuInS_2$) nano-particles have been synthesized by solvothermal method for absorption layer of solar cells. The $CuInS_2$ nano-particles can be adsorbed in pores of TiO_2 porous films. The effects of heat-treatment on crystalline structures and sizes of the $CuInS_2$ nano-particles were investigated. Crystalline structures and sizes were characterized by X-ray diffraction (XRD) and transmission electron microscope (TEM) investigations. Surface morphologies and optical properties have been studied by Field-emission scanning electron microscope (FESEM) and UV-Vis spectra when $CuInS_2$ were absorbed on TiO_2 films.

The results show that the $CuInS_2$ quantum dots (size is smaller than 10nm) can be synthesized by solvothermal method at 150℃. $CuInS_2$ particles sizes increase with the rise of reacting temperature and time. The $CuInS_2$ quantum dots can be adsorbed on TiO_2 films well and high-absorptive anodic electrode of solar cells can be prepared. Blue shift of absorption edge was observed as the sizes of $CuInS_2$ quantum dots decreased.

Introduction

Dye-sensitized solar cells (DSSCs) have attracted a great deal of interest during the past year . However, natural organic dyes have many shortcomings, narrow band gap inorganic semiconductor sensitizers have been concerned by more and more researchers, recently . $CuInS_2$ substituting for organic dyes in DSSCs is worth paying attention. In this paper, $CuInS_2$ has been synthesized by solvothermal method at low temperature, and can be adsorbed in pores of TiO_2 porous films well. The effects of heat-treatment on crystalline structures and sizes were investigated mostly.

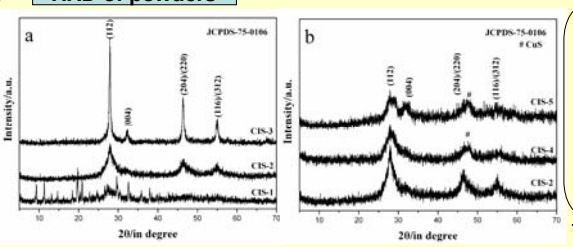
Experimental

1mmol CuCl, 1mmol $InCl_3 \cdot 4H_2O$ and 4mmol CH_4N_2S were dissolved in 80ml ethanol. The solution was added into a teflon-lined steel autoclave, and then sealed and maintained at different temperatures for different hours, air-cooled to room temperature. The obtained precipitate was centrifuged and washed several times with ethanol and then dried at 60℃ for several hours.

TiO_2 films were prepared by Doctor's blade technique using slurry of Degussa P25 powders on ITO coated glass substrate. Then the films were placed in precursor solution of $CuInS_2$, and maintained at 150℃ for 2hrs, 4hrs and 6hrs respectively. $CuInS_2$ nano-particles could be adsorbed on porous TiO_2 films well and formed compound films with TiO_2.

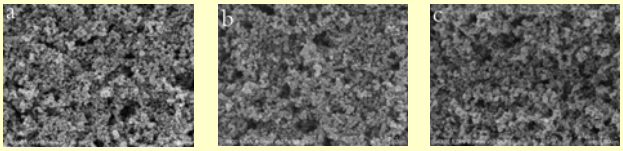
Results and Discussion

XRD of powders



a: At different temperatures for 6hrs:
CIS-1 is 120℃,
CIS-2 is 150 ℃,
CIS-3 is 180℃;
b: At 150℃for different times:
CIS-2 is 6hrs,
CIS-4 is 4hrs,
CIS-5 is 2hrs

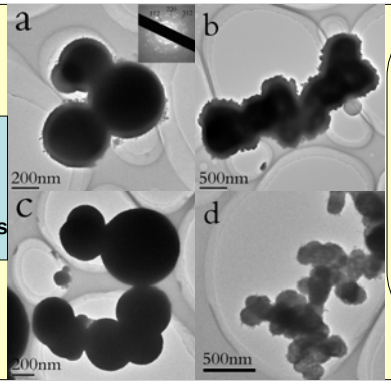
FESEM images of compound films



At 150℃ for 2hrs | At 150℃ for 4hrs | At 150℃ for 6hrs

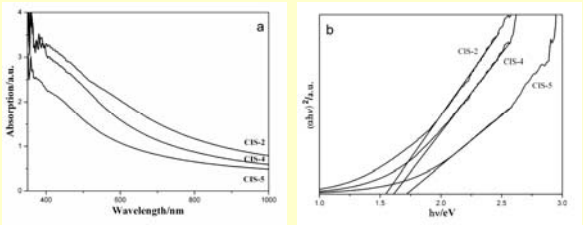
The diameter of pores was about 100~200nmm,
$CuInS_2$ particles could be adsorbed in the pores

TEM Images Of Powders



a: at 150℃ for 6hrs
380~510nm
b: at 180℃ for 6hrs
400~650nm
c: at 150℃ for 4hrs
320~450nm
d: at 150℃ for 2hrs
about 200nm

Optical absorbance of films and band gap



CIS-2 is at 150℃ for 6hrs, band gap is 1.54eV
CIS-4 is at 150℃ for 4hrs, band gap is 1.61eV
CIS-5 is at 150℃ for 2hrs, band gap is 1.72eV

Conclusions

$CuInS_2$ nano-particles were successfully synthesized by solvothermal method using ethanol as the solvent for absorption layer of solar cells at 150℃, and could be adsorbed in the pores of TiO_2 porous films.

At the same temperature, the nanocrystalline size increase with the reaction time extending, while for the same time, size increase with the temperature increasing.

With the size decreasing, the optical absorption edge of compound film has a blue shift, and the band gap ranges from 1.54eV to 1.72eV that marches with solar spectrum well.