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Quantized Nanocrystalline CdTe Thin Films

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Abstract: Nanocrystalline CdTe thin films were prepared by asymmetric rectangular pulse electrodeposition in organic solution at 110°C. STM image shows a porous network morphology constructed by interconnected spherical CdTe crystallites with a mean diameter of 4.2 nm. A pronounced size quantization was indicated in the action and absorption spectra. Potentials dependence dual conductive behavior was revealed in the photocurrent-potential (I-V) curves.

Keywords: nanocrystalline CdTe thin film, asymmetric rectangular pulse electrodeposition, size quantization, dual conductive behavior

Size quantized nanocrystalline semiconductor thin films have attracted considerable interest in the photoelectrochemical studies[1,2]. In this paper, we report a pronounced size quantization in nanocrystalline CdTe thin films which is less extensively studied.

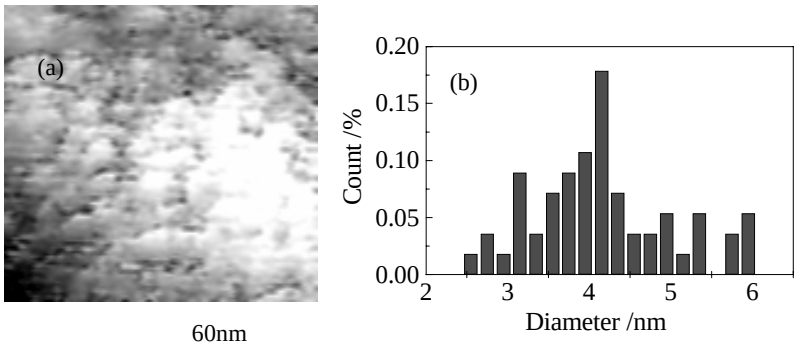
Nanocrystalline CdTe thin films were electrodeposited on conducting glass by asymmetric rectangular pulse in dimethylsulfoxide solution containing 6 mmol/L Te, 0.75 mmol/L $Cd(ClO_4)_2$, 18 mmol/L triphenylphosphine and 0.1 mol/L $LiClO_4$ at 110°C under N_2 purge. Pulse deposition was performed in conventional three electrode cell with saturated calomel reference and Pt counter electrodes at pulse potentials –1.10 V and –0.55 V and a pulse frequency 1 Hz. CdTe nanoparticles were deposited at the negative pulse –1.10 V and excess composition of Cd and Te were stripped at more positive pulse –0.55 V. The size of nanoparticles can be controlled facilely by changing the ratio of negative pulse width/positive pulse width (tc/ta). The nano-crystalline CdTe thin films were obtained after annealing at 200°C for 15 min in N_2.

A porous network morphology constructed by the interconnected spherical CdTe crystallites was observed in the STM images shown in **Figure 1(a)**[3]. From **Figure 1(a)**, the statistical histogram of size distribution was computed and displayed in **Figure 1(b)**. A mean diameter of CdTe crystallites was evaluated to be 4.2 nm. XRD spectrum of nanocrystalline CdTe thin film indicates a cubic crystalline structure without free Cd and Te.

The action spectrum and I-V behavior of nanocrystalline CdTe thin films were studied in polysulfide solution. **Figure 2(a)** shows the action and absorption spectra. We observed the action spectrum consistent with the absorption spectrum was shifted to 500 nm corresponding to the band energy of 2.48 eV. An increase in the band energy compared to the CdTe bulk materials (1.41 eV) indicates a pronounced size quantization in this films.

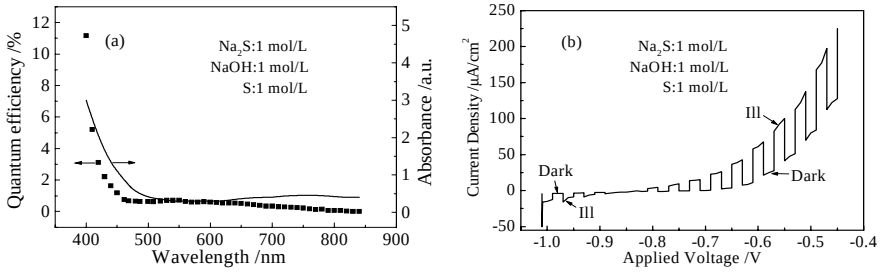
The I-V behavior of nanocrystalline CdTe thin films is given in **Figure 2(b)**. I-V

Figure 1 The STM image (a) and size distribution (b) tc/ta=1



V, and changed to p-type (cathodic photocurrent) response at the potential negative than –0.85 V. This results can be interpreted in terms of the transportation behaviors of photogenerated holes and electrons to the conducting glass substrate. Photogenerated electrons transport into the substrate facilely at the potential positive than –0.85 due to the Fermi level of the substrate moving down. As the potential shifts to negative than –0.85 V the Fermi level of the substrate moving up, the transportation to the substrate become easier for photogenerated holes than electrons resulting in a change of the photoresponse from n-type to p-type.

Figure 2 The action and absorption spectra (a) and I-V curves (b)



Nanoporous CdTe thin films with pronounced size quantization were electrodeposited by asymmetric rectangular pulse. The nanocrystalline CdTe thin films exhibited n-type conductive behavior at potential positive than –0.85 V and p-type at potential negative than –0.85 V.

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