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Amorphous Silicon Thin Film Solar Cell Utilizing ITO Patterned Electrode

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1. Introduction

The thin film solar cell has high potential to be an important technology due to low manufacture cost and the high throughput possibility. There are several kinds of material used in the thin film solar cell, such as amorphous silicon (a-Si), copper indium gallium selenide (CIGS), cadmium telluride (CdTe). Considering the environment protection, the a-Si is the best solution since that silicon is a stable element in our earth. However, even the a-Si material is a good candidate for thin film solar cell, it still has some problems to be solved, such as light-management, carrier collection, and carrier transportation. As result, thin film solar cell could enhance the power conversion efficiency by improving the incident light collection effectively [1]. Conventional, light-management approaches can be divided into two parts, antireflection and light trapping. The single layer antireflective coating has low reflection in a narrow wavelength range. Recently, nanostructure play a critical role in the antireflective structure due to the broadband wavelength range and the wide incident angle, such a sub wavelength structure (SWS) [2]. The SWS layer function as buffer layer between the air and the substrate with a graded refractive index profile, which can enhance the light transmission. The ITO nano-rod can provide a lower refractive index than the conventional ITO film due to the air volume mixed with the ITO nano-rods. Moreover, the ITO nanostructure also shows the scattering effect in the short wavelength, which can improve the absorption efficiency.

Here we introduce the a-Si solar cell with the new architecture, as the figure 1(a) shown. The new architecture consisted ITO nanorods patterned front electrode, the ITO patterned electrode can provide buffer layer between the ITO film and glass substrate, which used to enhance the light transmission. Followed by the deposition the ITO film on the ITO nanorods, the ITO film would cover the ITO rods and form a ball-shape structure. We have fabricated the ITO film layer on the ITO rods. As the figure 1(b) show the cross-sectional view of the thin film solar cell.

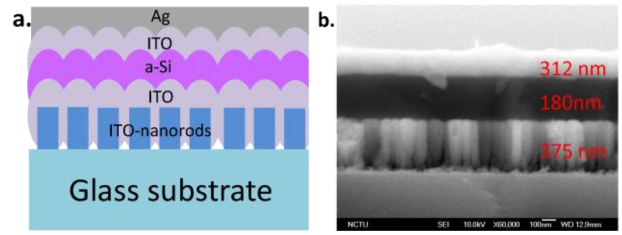

Fig. 1 (a)The schematic of amorphous silicon thin film solar cell utilizing the ITO nano-rods patterned electrode. (b) Scanning electron microscopic (SEM) image of the amorphous silicon thin film solar cell

2. Experimental

The schematic of device fabricated is shown as fig. 1(a). The ITO sub wavelength structure is deposited on the glass substrate with two parts deposition. Firstly, the ITO nano-rods structure would be deposited on the substrate using electron-beam evaporation. The glass is attached to a holder, which was tilted at a deposition angle of 70 with respect to the incident vapor flux. In these structures, the growth mechanism presumably involves a tin-induced self- catalytic vapor-liquid-solid (VLS) [3] process, which is still under investigation. In theory, the growth of ITO nano-rods can be divided into two steps: nucleation and rod growth as shown in figure 2

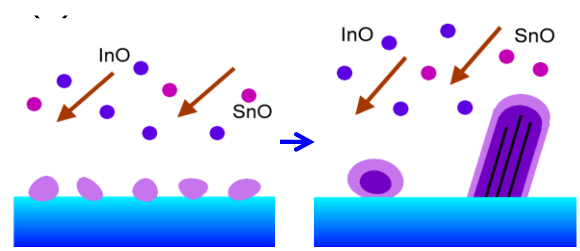

Fig.2 growth mechanism of ITO whiskers breaks into three main step: (a) the nucleation, (b) rod growth.

We prepared ITO nano-rod glass with two different deposition times: 200 and 330 seconds, that the lengths of nano-rods are about 120 nm and 200nm. The second step is depositing an ITO film on the ITO nano-rods with sputter. The ITO film is covered on the ITO nano-rods compactly that the structure is like a group of hemispheres as shown in figure 3. We attempted two thicknesses 160 nm 1nd 300 nm to compare which ITO film thickness is suitable for the structure. The thicker ITO film covered would make the structure shape gradual, and the longer nano-rods make the hemisphere structure have a larger radius and the transmittance as shown in figure 3(e).

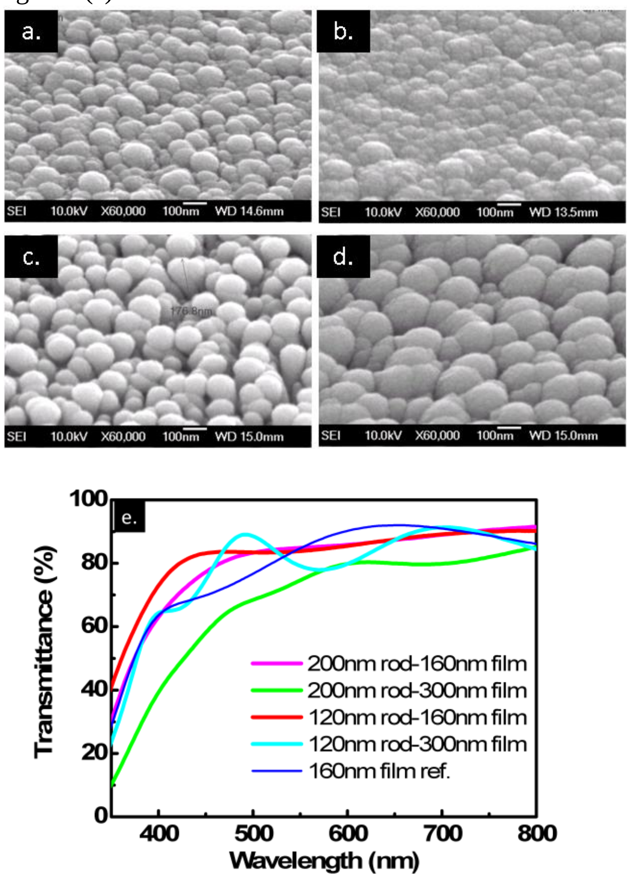

Fig. 3 SEM image of ITO sub wavelength structure and its transmittance. (a) 120 nm rod with 160 nm film. (b) 120 nm rod with 300 nm film. (c) 200 nm rod with 160 nm film. (d) 200 nm rod with 300 nm film. (e) The transmittance of structures

Eventually, we deposited the amorphous silicon p-i-n layer on the ITO patterned electrode substrate as an active layer. Then we deposited the other ITO film and Al film as a back electrode and back reflector, as shown in figure 1(b).

Figure 4 shows the absorption of amorphous layer of our sample. Compared to the reference amorphous thin film cell which has a 160 nm flat ITO film as front electrode, the absorption has an evident gain in visible and IR region. The ITO sub wavelength structure causes the refractive index has a gradual change between ITO and amorphous silicon, regarded as a broadband antireflective coating [4] that reduce the reflectance in this interface. In addition, the sub wavelength structures make incident light scattering into the cell that light would be trapping in active layer to increase the optical path. Because of the shorter nano-rods structure has smaller hemisphere structure, the effect of gradual interface is not oblivious that the gain of absorption is worse than the longer one.

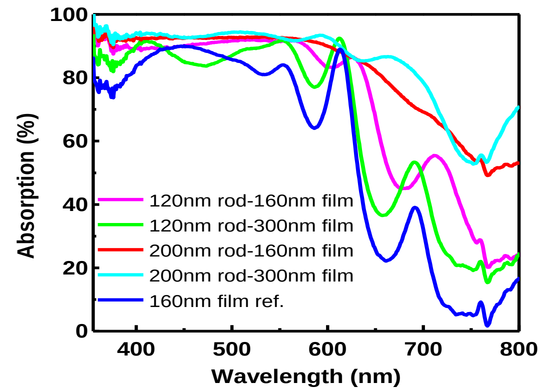

Fig.4 The absorption of active layers of amorphous thin film solar cell with ITO patterned electrode.

3.Conclusions

The ITO patterned electrode serve superior antireflection and light trapping properties in amorphous silicon thin film solar cell. The cell has better absorption efficiency than reference sample. And the fabricated of ITO patterned electrode is simple and it is suitable to thin film solar cell with another material.

Acknowledgements

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