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Novel deposition method of anti-reflective coating for spherical silicon solar cells

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Abstract

The liquid-phase deposition (LPD) as a novel deposition method of anti-reflective coating (ARC) for spherical silicon solar cells has been proposed. The LPD is a growth method in aqueous solution and can deposit thin films with uniform coverage over a spherical surface. The solar cell performance of the spherical silicon solar cell with an ARC shows more than 10% increase in short-circuit current density compared to that without an ARC. The result confirms that the LPD method is useful for ARC fabrications of spherical silicon solar cells.

Keywords: Spherical si; Solar cell; Anti-reflective coating

1. Introduction

Spherical silicon solar cells have gathered much attention as a promising candidate for high performance with low-cost solar cells. We proposed the new type of a spherical silicon solar cell with semi-concentration reflector system [1]. Anti-reflective coating (ARC) is one of the most important processes to enhance short-circuit current density J_{sc} by reducing the reflection at the surface of a solar cell. Fabrication methods of ARCs for conventional solar cells with a flat surface, e.g., physical vapor deposition, chemical vapor deposition and sol–gel method, etc., are not suitable for spherical Si solar cells because these methods

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cannot deposit uniform ARC layers over spherical objects effectively. We have proposed the application of liquid-phase deposition (LPD) for the novel fabrication method of ARCs especially for spherical Si solar cells. The LPD is a growth method for thin films in an aqueous solution, and also known as chemical bath deposition which is utilized in the deposition of CdS buffer layers in Cu(In,Ga)Se_2 solar cells [2]. The LPD method has not been utilized in ARC fabrications because the films fabricated by the LPD shows poor uniformity for large area; however, it can be ideal for spherical silicon solar cells because of the small size of silicon spheres as the diameter of 1 mm and the ability to deposit uniform thin film over any surface. In this contribution, the fabrication of ARCs on Si spheres and the solar cell performance of spherical Si solar cell with the ARC are discussed.

2. Experimental

Fig. 1 shows the schematic apparatus of the LPD method in this work. The deposition process is simple; firstly a water bath is warmed up at certain temperature, and then a glass beaker (growth bath) containing a chemical solution is soaked in the water bath, at the same time substrates are immersed in the beaker and a film deposition is done for certain duration. Here, a CdS thin film is utilized as an ARC for its well-understood deposition mechanism [3–6]. The chemical solution for the CdS deposition consists of four chemicals; 0.001 M (mol/l) $Cd(CH_3COO)_2 \cdot 2H_2O$, 0.005 M $(NH_2)_2CS$, 0.01 M CH_3COONH_4 and 0.4 M NH_4OH. The growth temperature and duration are 80 °C and 13 min, respectively. The films were deposited on Si spheres and Si wafers to investigate film coverage, surface morphology and reflectance.

In order to demonstrate the viability of the LPD method in solar cell applications, spherical Si solar cells were fabricated as shown in Fig. 2. After our baseline process for solar cell fabrications, not fully optimized yet, including phosphorous diffusion and pn separation, etc., CdS thin films were deposited on the silicon spheres. Finally, spherical silicon solar cells were completed by sphere arrangements with reflectors and electrode connections. Here, single-crystalline silicon spheres fabricated from a Czochralski silicon wafer by cutting into dices and polishing into spheres were used for photovoltaic parts.

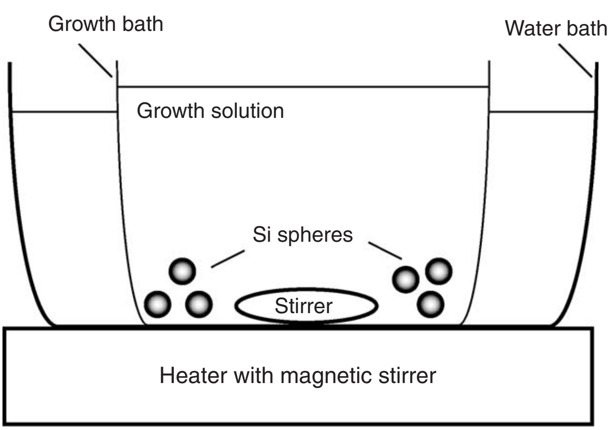

Fig. 1. Schematic apparatus of the LPD method.