Fabrication of Dye-Sensitized Solar Cells by Spray Pyrolysis Deposition Technique

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1. Introduction

A dye-sensitized solar cell has been a hot topic during the decade due to its scientific and technological importance. In order to fabricate the solar cell in a practical use, a novel industrial electrode production technique should be developed. Among many thin film processing techniques, a spray pyrolysis deposition (SPD) technique is one of the most promising ones, since the film formation is carried out in air by a simple apparatus. We report here a fabrication of working electrodes of dye-sensitized solar cells by depositing TiO_2 layer on SnO_2:F transparent conducting layer, both of which are prepared by SPD technique

2. Experimental

Transparent conducting SnO_2:F layers were prepared from di-*n*-butyltin(IV) diacetate ethanol solution with ammonium fluoride as an additive [1, 2]. The source solution was sprayed by a compressed air onto the heated glass substrate (Corning 1737; 25×25×1 mm^3 in size). The mist was pyrolized on the substrate to form SnO_2:F film in air. Since the mist cooled down the substrate, the spraying was not carried out continuously but intermittently. Porous TiO_2 layer was deposited on SnO_2:F layer in the same way that mentioned above from the mixture of aqueous amorphous and anatase TiO_2-sols (TKC-01 and –02, respectively, TAYCA Co., Ltd.). Ruthenium(II) *cis*-di(thiocyano)bis(2,2'-bipyridyl-4,4'-dicarboxylic acid) dye was adsorbed on the surface of TiO_2 films by refluxing electrodes in the ethanol solution. The amount of dye adsorbed on TiO_2 film was evaluated by colorimetry. An anhydrous electrolyte containing I^-/I_3^- was sandwiched between dye-adsorbed TiO_2 electrode and platinum coated glass to construct a dye-sensitized solar cell [3]. The current-voltage characteristic measurements were done under the quasi light of AM-1.5 and 100 mW/cm^2 illumination.

3. Results

It was difficult to prepare TiO_2 film with high quality only from anatase sol, since the film was powdery and removed easily from the substrate. On the other hand, the film from amorphous sol attached firmly on a glass substrate due to the grain growth attributed to the phase transition from amorphous to anatase. However, the surface morphology of the film was smooth as shown in Fig. 2. The porosity of TiO_2 film was controlled by changing [anatase]/[amorphous] ratio in the source solution. In the conventional thin film processing technique, such as dip-coating and doctor blade, after coating a substrate with precursor in many times including a short rest to dry it up, the substrate is pre-annealed and then sintered for at least 1 hour to prepare films. On the other hand, by utilizing SPD technique, quick TiO_2 thin film preparation was accomplished from aqueous TiO_2-sols. Since TiO_2 neck is produced within a few seconds of waiting period during the intermittent spraying in SPD, it is possible to prepare 10 μm-thick TiO_2 film within 10 minutes. Dye-sensitized solar cells were fabricated with the films. The conversion efficiency was enhanced as high as 6% by optimizing [anatase]/[amorphous] ratio.

References

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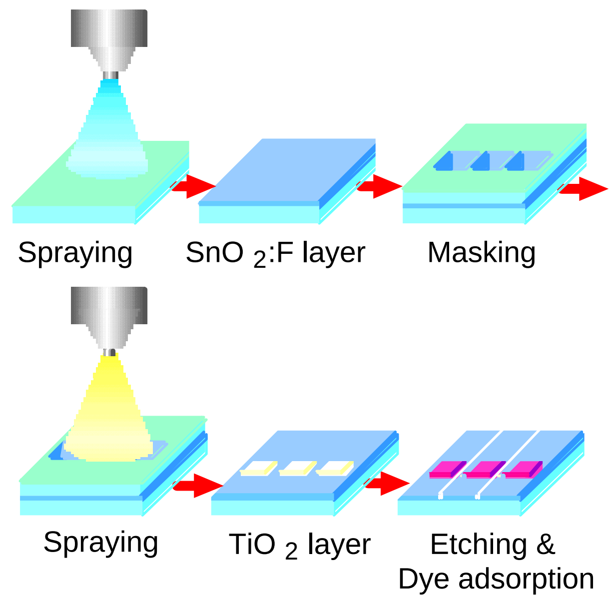

Fig. 1 Continuous process of working electrodes by SPD technique.

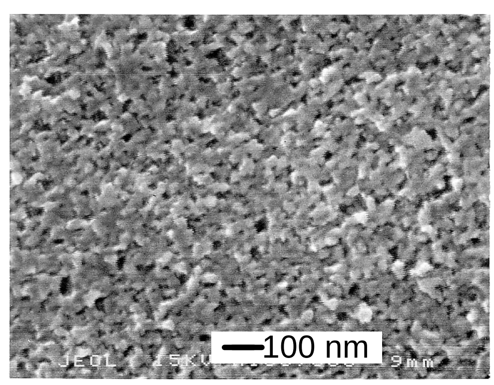

Fig. 2 SEM images of the surface morphology of TiO2 films prepared by SPD technique from the mixture sol at the ratio [anatase]/[amorphous]=2.3.