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Microwave Sinetering of Nano TiO_2 for Flexible Dye-Sensitized Solar Cells

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Introduction

The dye-sensitized solar cell unveiled by Gräzel et al. in 1991 has attracted much attention as the next-generation solar cell [1, 2]. Remarkably high quantum efficiency in combination with the expected ease and low cost of manufacturing makes this new technology interesting as an alternative to existent solar cell technologies. Various aspects of dye-sensitized solar cells have therefore been researched, including the sensitized dye, semiconductor particles, electrolyte, electron transfer process and photovoltaic mechanism.

In spite of these vigorous studies, the assembling of flexible TiO_2/dye solar cell is still under investigation. Flexible electrodes, like poly ethylene terephthalate sheet coated with tin-doped indium oxide (PET-ITO), present lower costs and technological advantages relative to conductive glass electrodes, e.g. lower weight, impact resistance and less form and shape limitations. However, deposition of nano particulated TiO_2 on PET-ITO is difficult, because the thermal treatment must be limited to 150 °C, decreasing adhesion, electrical contact between the particles and adsorption of the dye.

To achieve the selective heating of organic-inorganic composite film, microwave processing is an attractive field in modern material science. Various inorganic phases have been synthesized using microwave ovens operating at a frequency of 2.45 GHz. This technique was also applied to the preparation of nano size TiO_2 powder with a high degree of crystallinity and monodispersed crystallite sizes [3, 4]. Recently the use of 28 GHz microwaves has been demonstrated to be effective in the synthesis of various inorganic oxides [5-8]. In these cases, reactions proceed rapidly via microwave-material interactions. Here, in this work, a 28 GHz microwave irradiation process for flexible dye-sensitized solar cells is newly proposed.

Experimental

For flexible type of solar cells, titanium oxide pastes were prepared by hydrothermal treatment of titanium oxide slurry (TAYCA Corp., TKS-203, pH=7) at 225 °C for 20 h. After the reaction, the particle size of the titanium oxide colloid was about 30 nm in diameter.

To measure photovoltaic properties, the synthesized titanium oxide paste was applied without any additives to FTO, fluorine doped SnO_2 coated transparent conductive glass plate having a sheet resistance of 15 □·cm^{-2}. The dimensions of the FTO glass size were 25 × 25 × 1.1 mm, and titanium oxide paste was applied to a 4 × 5 mm rectangular surface region to a thickness of about 60 µm. The titanium oxide film was then heated using the multi-mode microwave heating system operating at a frequency of 28 GHz (Model FMS-10-28, Fuji Dempa Kogyo Co., Ltd., Japan) for 5 min.

Result and Discussion

The apparatus of 28 GHz microwave heating system is shown in Fig. 1. The resulted all-plastic flexible dye-sensitized solar cell is shown in Fig. 2. The cell performance improved by microwave heating from 0.45 % to 0.74 %at 2.45 GHz, and up to 2.16 % at 28 GHz. Relatively high open circuit voltage of 685 mV at 28 GHz irradiation is considered to the better electrical connectivity of each nano size TiO_2 particles. This well firing resulted higher photo-electron conversion efficiency.

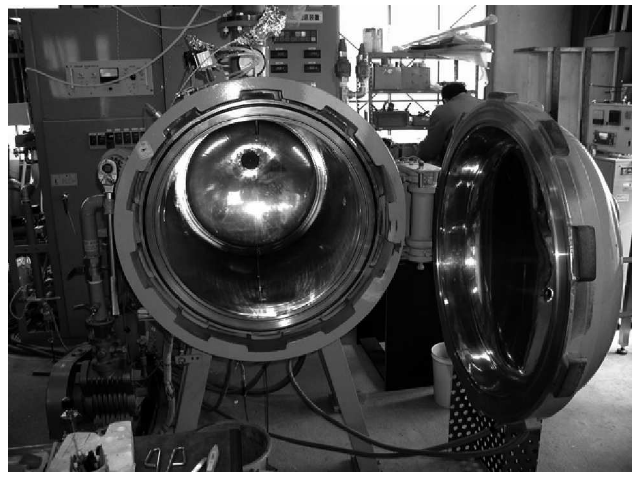

Fig. 1 28 GHz Microwave sintering furnace (Model FMS-10-28, Fuji Dempa Kogyo Co., Ltd., Japan).

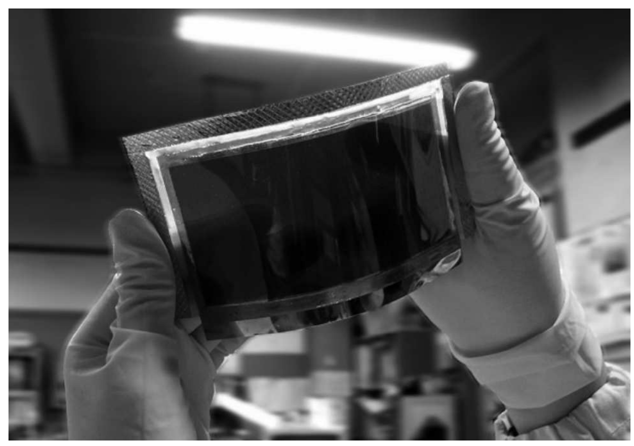

Fig. 2 Example of all-plastic flexible DSSC cell.

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