ESQSEC2008 Abstract (Hitachi)

Organic photovoltaic devices utilizing nano-size controlled materials

Naoki Yoshimoto, Hiroto Naito, Masahiko Ando*, and Akiyoshi Komura
Advanced Research Laboratory, Hitachi, Ltd., Ibaraki, Japan
*Hitachi Cambridge Laboratory, Cambridge, UK

1. Introduction

In order to improve the performance of organic photovoltaic devices such as dye sensitized solar cells and thin film solar cells with bulk hetero-junction, we have applied nano-size controlled materials to these devices and optimized the device structures in collaboration with Kyoto University under the integrative industry-academia partnership (IIAP) since 2003. These materials were made by using solution process in which sizes of nanoparticles and thickness of stacked layers were precisely controlled utilizing the principle of self-organization and self-assembly of molecules.

2. Dye sensitized solar cells

By using reacting field induced by surfactant in precursor solution, anatase -type TiO_2 nanocrystals with diameter less than 10 nm were grown in solution process[1), 2)]. TiO_2 thin films were fabricated by repetitive coating and calcinations and the surface area and the internal resistance became four times larger and one eighth smaller respectively compared with those using conventional TiO_2 nanocrystals with average diameter at 30 nm and lower crystallinity. In order to satisfy both (1) light absorption of dyes adsorbed at surface of TiO_2 nanocrystals and (2) infiltration of electrolyte into pores made between TiO_2 nanocrystals, two TiO_2 thin films composed of nanocrystals with smaller diameter (<30 nm) and with larger diameter (30-100 nm) were stacked and each thickness was optimized to maximize the photovoltaic performance. Maximum photovoltaic efficiency at 10.3 % was obtained with 0.25 cm^2 area.

In order to scale up the solar cell size, internal resistance was reduced by using (1) Ti patterned plate for the counter electrode, and (2) metal grid electrodes on transparent conducting electrode. The reduction of the internal resistance minimized the reduction of photovoltaic efficiency with scale up and only 11% decreasing of loss in comparison with small size (0.25 cm^2 active area) was obtained at 36 cm^2, one of the highest values in the world at the same size scale[3)].

3. Thin film solar cells

To some applications such as photovoltaic power supply for in-door sheet type

photodiodes, higher open-circuit voltage is required rather than higher short-circuit current. In order to increase the open circuit voltage of thin film solar cells with bulk heterojunction made of P3HT/PCBM system, poly (p-phenylenevinylene) (PPV) thin films were made by using layer-by-layer deposition method and inserted between the bulk-heterojunction and the transparent electrode[4]. By post annealing at 140 C, the conversion efficiency at 1.77% was obtained with the open circuit voltage increased at about 200 mV. Precisely controlled thickness of the PPV film at about 20 nm increased the open-circuit voltage with minimized decrease in the short circuit current of the devices.

References

1) J. Jiu, et al., J. Electrochem. Soc. **151**, A1653(2004).
2) J. Jiu, et al., Solar Energy Mater. & Solar Cells **87**, 77(2005).
3) N. Yoshimoto, et al., to be submitted.
4) M. Ogawa, et al., Appl. Phys. Lett. **90**, 223107(2007).