Area5, Perovskite Solar Cells

203mm×203mm largest sized highly efficient $MAPbI_3$ solar module

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Large size organic - inorganic halide perovskite solar modules were fabricated. We used $CH_3NH_3PbI_3$ as light absorbers, mesoporous TiO_2 as ETM (n type) and SpiroOMeTAD as HTM (p type) and realized a cascade connection structure of 35 cells on the largest 203 mm square glass substrate as the perovskite solar modules. We achieved an efficiency of 12.6% with the largest sized perovskite module.

The module configuration we used for experiments is shown in Fig. 1. FTO films and compact TiO_2 films coated glasses with a size of 203 mm×203 mm×0.5 t were used for a substrate. The FTO films were scribed with a wavelength of 1.06 μm YAG laser to form P1-grooves (width 75 μm, pitch 200 μm) . Subsequently, 10 mL of a dispersion ethanol solution of TiO_2 nanoparticles was spin-coated to form mesoporous TiO_2 layers. Subsequently, 10 mL of a 0.7 M $CH_3NH_3PbI_3$ / DMSO solution was spin coated, drip treatment was performed with 10 mL of toluene, and heat treatment was performed on a hot plate at 100 ° C for 60 min. A 500 nm thick $CH_3NH_3PbI_3$ film was formed and further spin-coated with 7.5 mL of Spiro OMeTAD / chlorobenzene solution containing Li-TFSI and Co-PF_6 to form a Spiro OMeTAD film. After P2-grooves (width 200 μm) were formed by mechanical scribing with a super steel blade, an Au vapor deposited film with a thickness of 200 nm was formed, and furthermore a mechanical scribe with a super steel blade similarly formed P3-groove to separate the cells. Figure 2 shows the picture of the perovskite module.

I-V curves of the modules are shown in Fig. 3. The module with Au/TiO_2/FTO contacts on P2 showed an efficiency of 9.4% (Voc=35.85V, Jsc=170.2mA, FF=54.7%, red curve). The low FF is attributed to the high contact resistance Rc of Au/TiO_2/FTO on P2 measured to be about 0.5Ωcm^2. In order to decrease the Rc of P2, the TiO_2 and FTO films were mixed by THG-YAG laser irradiation. The Rc of Au/TiO_2/FTO decreased down to 0.1Ωcm^2 by the laser irradiation. An efficiency of the module increased up to 12.6% (Voc=38.60V , Jsc=167.0mA, FF=69.2% ,blue curve) by reduction of the Rc on P2. Here, an average Voc /cell of 1.103 V is equivalent with a small sized cell. This result indicates that uniform cell performances can be obtained by the coating process in a large area.

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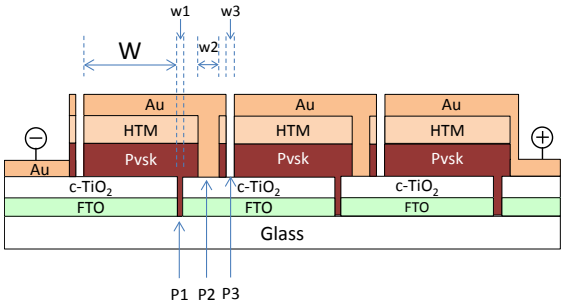

Figure 1: Schematic of perovskite solar module. TiO_2 layer remains between Au and FTO.

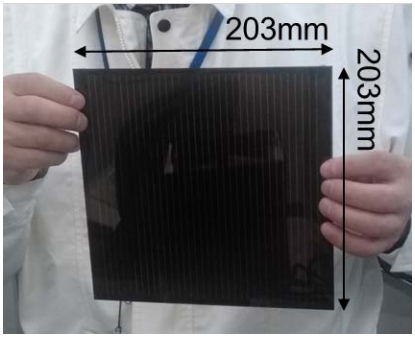

Figure 2: Perovskite module

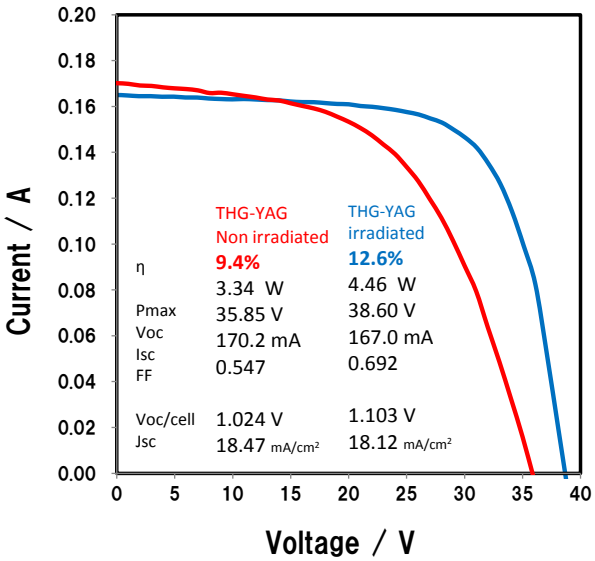

Figure 3: I-V curves of modules with (blue curve) and without (red curve) THG-YAG treatment on P2 part of TiO_2 layer.