Enhanced Performance of Organic Thin-Film Solar Cells with Gold Quantum Dots-Gold Nanoparticles

Niigata Univ. [1], Chiang Mai Univ. [2], ◦Sopit Phetsang[1,2], Apichat Pangdam[1], Pitchaya Mungkornasawakul[2], Kontad Ounnunkad[2], Chutiparn Lertvachirapaiboon[1], Kazunari Shinbo[1], Keizo Kato[1], Futao Kaneko[1], and Akira Baba[1*]

E-mail: ababa@eng.niigata-u.ac.jp

An enhancement of the optical and electrical property in organic solar cells have been studied via several techniques including the incorporation of metallic nanoparticles and the construction of plasmonic nanostructures into the photovoltaic device.(1-3) Gold nanoparticles (AuNPs) play an important role for improving light harvesting efficiency in the organic solar cells caused by the excitation of localized surface plasmon resonance (LSPR) which is dependent on the size and shape of nanoparticles. On the other hand, the LSPR phenomenon cannot be observed as the particles size decreases with a diameter less than 2 nm, which is called gold clusters or gold quantum dots (AuQDs). AuQDs exhibits a quantum size effect such a light absorption and photoluminescence phenomena. Moreover, the quantum size could also enhance the charge mobility within the organic solar cells. Due to a variety of the optical property from AuNPs, we focused on the improvement of the efficiency of organic thin-film solar cells by incorporating AuNPs and AuQDs (Blue-AuQDs, Green-AuQDs, and Red-AuQDs). In this work, the developed solar cells; Al/P3HT:PCBM/AuNPs: PEDOT:PSS/AuQDs/ITO glass substrate have been investigated (Fig.1a). The results demonstrated that the developing cell provided better efficiency observed by increasing the short circuit current density (J_{SC}) and power conversion efficiency (PCE) in comparison with the reference cell as shown in Fig. 1b. This indicates that additional nanoparticles into the device can enhance the light absorption of the solar cell. In particular, the fluorescence emission of AuQDs under UV irradiation on the glass substrate (Fig. 1c) was clearly confirmed, indicating that loading AuQDs shows UV light-harvesting in this system.

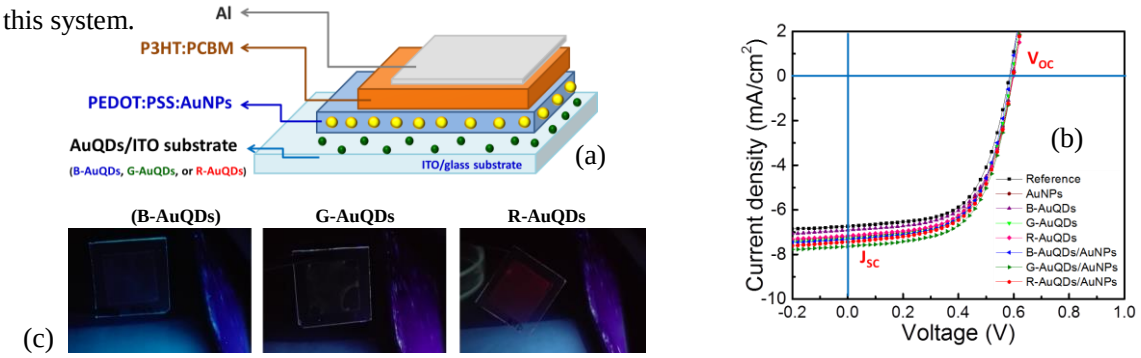

Fig. 1 Structure of fabricated device (a), *J-V* curves of developing solar cells (b), and photoluminescence of AuQDs films (c).

References;
(1) A. Pangdam, S. Nootchanat, R. Ishikawa, K. Shinbo, K. Kato, F. Kaneko, C. Thammacharoen, S. Ekgasit, A. Baba, Phys. Chem. Chem. Phys., 18, 18500 (2016).
(2) S. Nootchanat, H. Ninsonti, A. Baba, S. Ekgasit, C. Thammacharoen, K. Shinbo, K. Kato, F. Kaneko, Phys. Chem. Chem. Phys., 16, 24484 (2014).
(3) A. Baba, N. Aoki, K. Shinbo, K. Kato, F. Kaneko, ACS Appl. Mater. Interfaces., 3, 2080 (2011).