Preparation of photoelectrodes with periodic micro-structure

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In solar cells, it is important to generate photo-excited charge carriers effectively and utilize them to achieve high photovoltaic performance. One of the methods to improve the performance of the solar cells is to separate the charge carriers to reduce electron-hole recombination and it has been reported that the substrates with organized periodic structure can be used to enhance the charge separation.[1] However, it has not been well understood the correlation between the inhomogeneous structure and the excitation and motion of the charge carriers and how it influences the performance. In the present study, we prepared a substrate with a periodic structure using TiO_2 particles with a homogeneous micron-size, extending the area over 1 cm^2, and evaluate them by a microscopic spectroscopy. We successfully prepared a colloid crystal substrate with 1 μm polystyrene (PS) particles on a FTO substrate with a TiO_2 blocking layer and further fabricated it into a TiO_2 inverse opal substrate with the area on the cm-scale (1.2×2.5 cm^2).

At first, we prepared a colloid crystal substrate by using 5 wt% mono-dispersed PS particles suspension and a FTO substrate coated with a TiO_2 blocking layer, which is made of TiO_2 nanoparticles and necessary to prevent the leak current. The diameter of the PS particles was 1 μm and the solvent of the suspension was water. For a hydrophilic treatment, we applied plasma on the substrate before using it. We diluted the suspension 5 times and immersed the substrate in it with a standing position at an angle of 50° to the horizontal plane. Then we heated it up to 65°C in an electric furnace for 24 hours and evaporated the solvent. After the preparation of the colloid crystal substrate, we fabricated it into a TiO_2 inverse opal substrate. We added a drop of 0.025M $TiCl_4$ solution (30 μL) in methanol onto the colloid crystal surface. After hydrolysis for 30 minutes, we heated the substrate up to 65 °C for 10 minutes. This procedure was repeated 3 times. Finally we heated the substrate up to 450 °C for an hour with a heating rate of 0.5 °C/min.[2] We successfully prepared the colloid crystal substrate and the TiO_2 inverse opal substrate on a cm-scale (1.2×2.5 cm^2) as shown Fig. 1. At present, we evaluate the structural dependence of the photoexcited carriers for the TiO_2 inverse opal substrates and the results will be discussed in the conference.

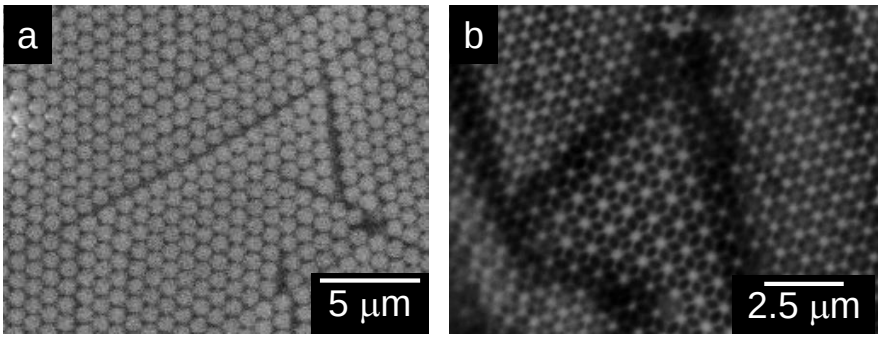

Figure 1. SEM images of (a) a colloid crystal substrate and (b) an inverse opal structure fabricated from the substrate (a)

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References:

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