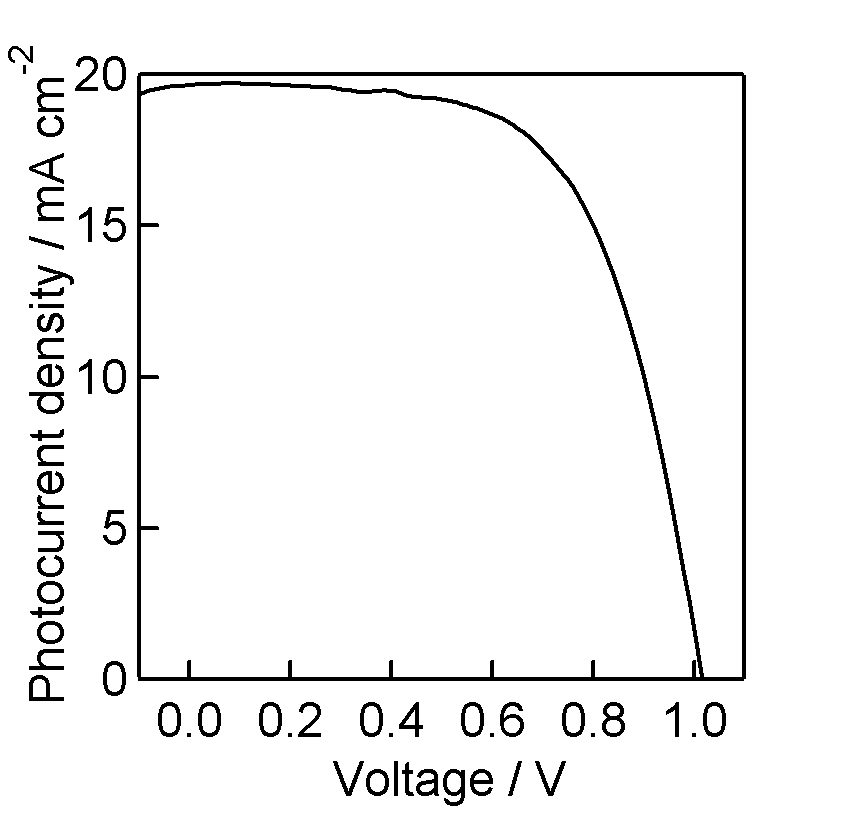
**CH3NH3PbI3 Perovskite Solar Cells using CuSCN Inorganic Hole Transmitting Layer**

Seigo Ito

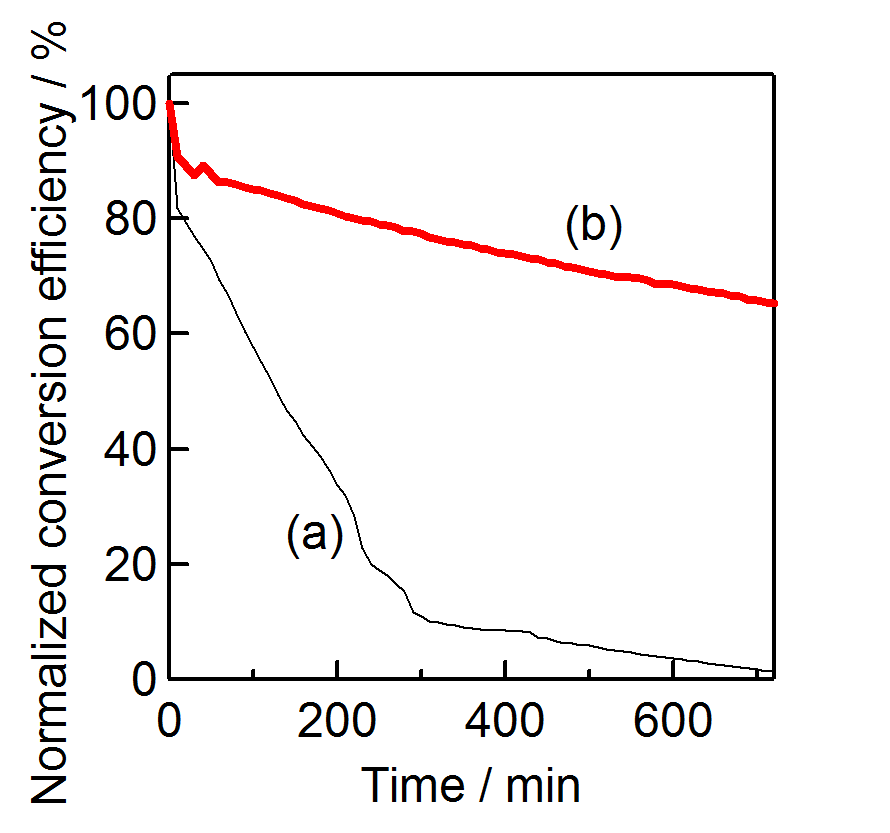
Department of Electrical Engineering and Computer Sciences,Graduate School of Engineering, University of Hyogo. 2167 Shosha, Himeji, Hyogo, 671-2280 JAPAN.

Email: itou@eng.u-hyogo.ac.jp

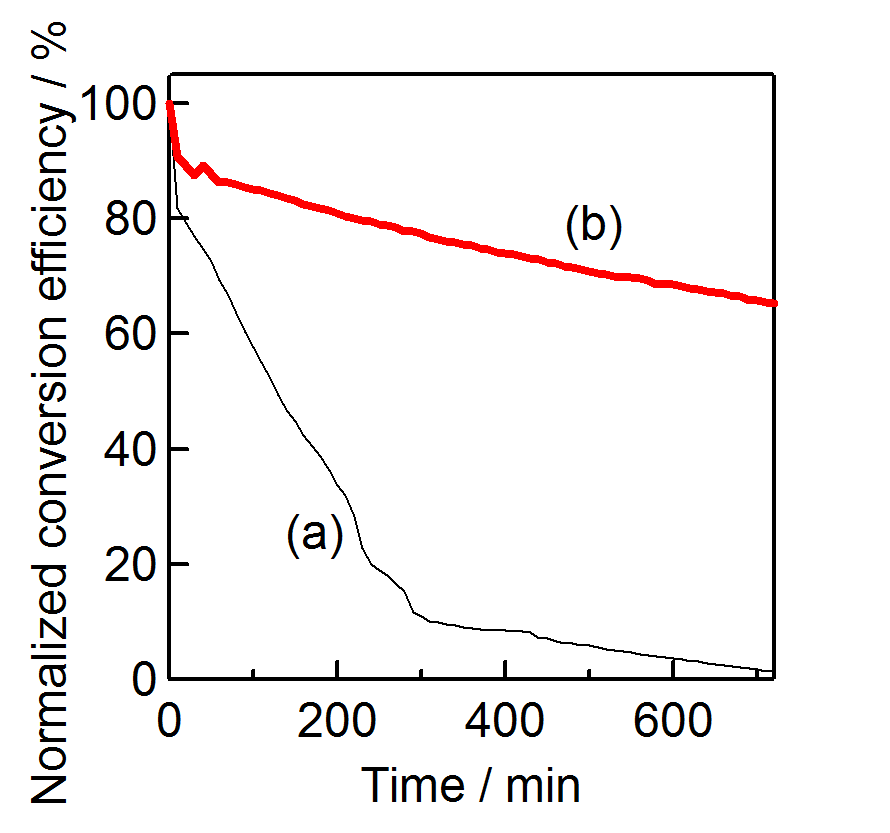
Despite the rapid increase in efficiency of the hybrid organic-inorganic methylammonium lead halide perovskites (CH3NH3PbI3, X = Cl-, Br-, I-) solar cells, the hole transporting material (HTM) used were mainly limited to organic compounds, the start-of-the-art 2,2’,7,7’-tetrakis(N,N-di-p-methoxyphenylamine)-9,9’-spirobifluorene (spiro-MeOTAD) and conducting polymers. Compared to organic HTMs, inorganic p-type semiconductors appear to be an ideal choice from the point of view of high mobility, stability ease of synthesis and low cost. Here, we report that combining the perovskite CH3NH3PbI3 with CuSCN as p-type HTM lead to solar cells with very high power conversion efficiency (12.4%) under full sun illumination (Fig. 1). Moreover, to improve the stability, Sb2S3 layers were inserted at the interface between TiO2 and CH3NH3PbI3 perovskite to be CH3NH3PbI3 solar cells using inorganic hole transporting material (CuSCN) (Fig. 2). The CH3NH3PbI3 layer was spin-coated by one-drop method on nanocrystalline TiO2 layer. During the light exposure test without encapsulation, the CH3NH3PbI3 solar cells without Sb2S3 deteriorated to zero efficiency in 12 h and were completely changed from black to yellow, because the perovskite CH3NH3PbI3 was changed to hexagonal PbI2. With Sb2S3, on the other hand, the CH3NH3PbI3 solar cells became stable against light exposure without encapsulation, which didn’t change the crystal structure and the wavelength edges of absorption and IPCE. Therefore, it was considered that the degradation can occur at the interface between TiO2 and CH3NH3PbI3.



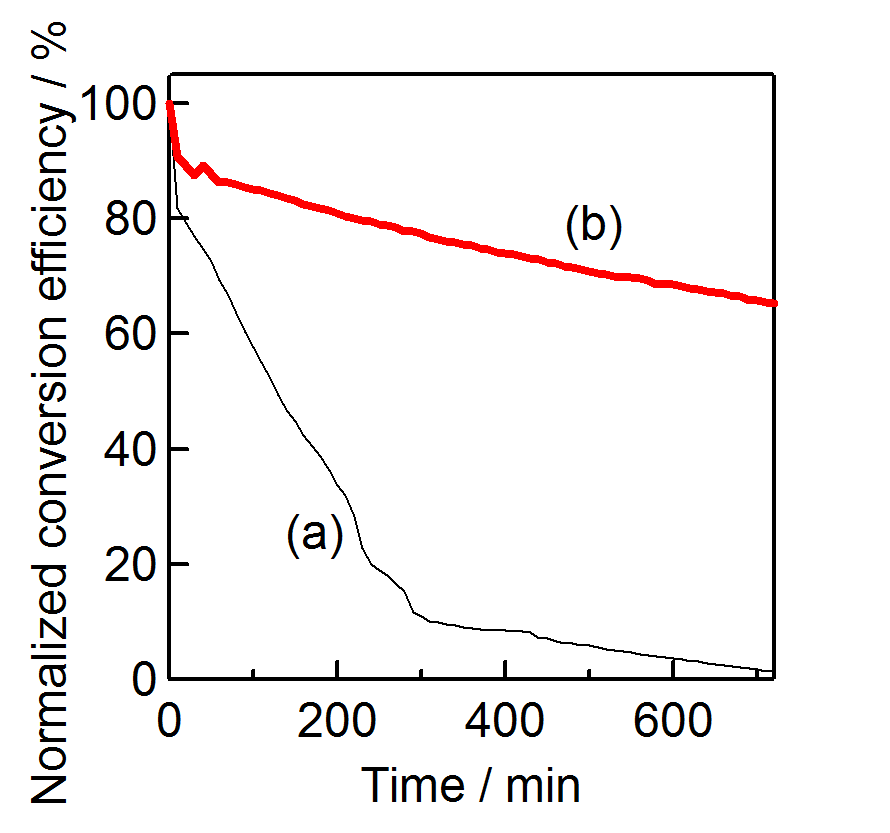
**Fig. 1.** Photo current density-voltage curve of CH3NH3PbI3 perovskite solar cells using CuSCN hole-transporting material.



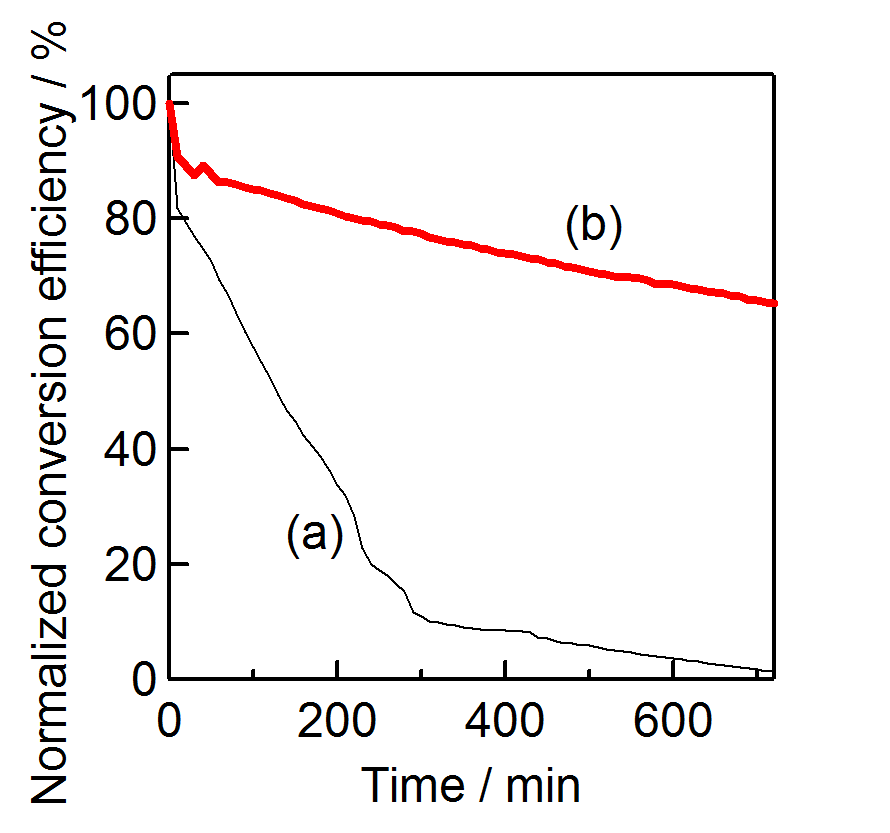
**Fig. 2.** Variation of photoenergy conversion efficiencies of solar cells during light exposure (AM1.5, 100 mW cm-2) without encapsulation in air for 12 hours: (a) <FTO/TiO2/CH3NH3PbI3/CuSCN/Au>; (b) <FTO/TiO2/Sb2S3/ CH3NH3PbI3/ CuSCN/Au>.



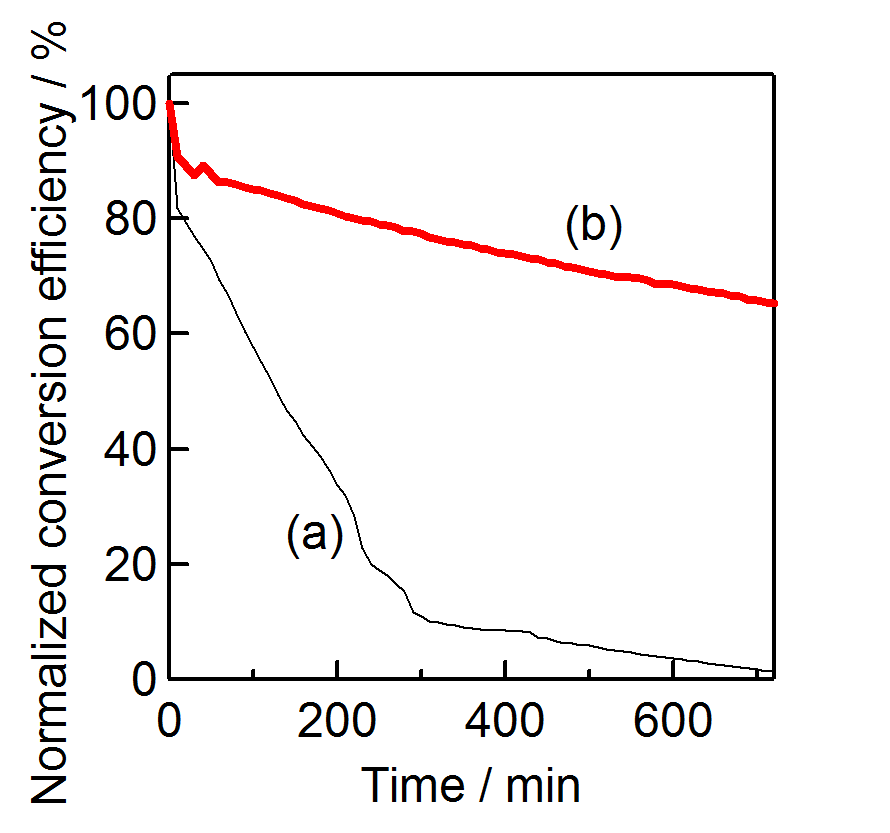
**Fig. 2.** Variation of photoenergy conversion efficiencies of solar cells during light exposure (AM1.5, 100 mW cm-2) without encapsulation in air for 12 hours: (a) <FTO/TiO2/CH3NH3PbI3/CuSCN/Au>; (b) <FTO/TiO2/Sb2S3/ CH3NH3PbI3/ CuSCN/Au>.



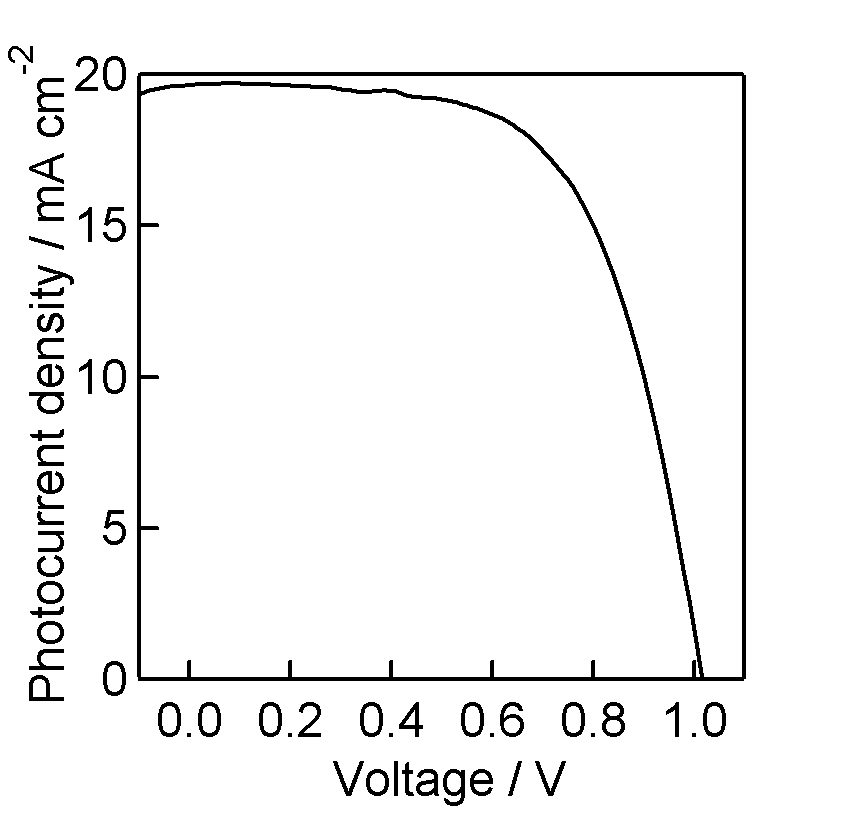
**Fig. 2.** Variation of photoenergy conversion efficiencies of solar cells during light exposure (AM1.5, 100 mW cm-2) without encapsulation in air for 12 hours: (a) <FTO/TiO2/CH3NH3PbI3/CuSCN/Au>; (b) <FTO/TiO2/Sb2S3/ CH3NH3PbI3/ CuSCN/Au>.



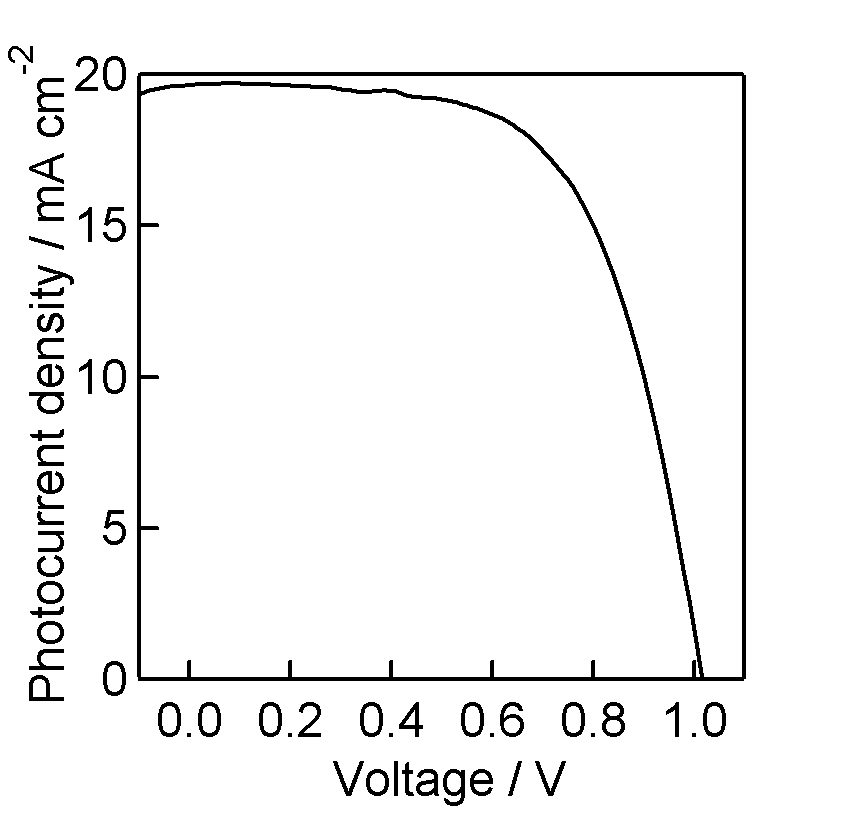
**Fig. 2.** Variation of photoenergy conversion efficiencies of solar cells during light exposure (AM1.5, 100 mW cm-2) without encapsulation in air for 12 hours: (a) <FTO/TiO2/CH3NH3PbI3/CuSCN/Au>; (b) <FTO/TiO2/Sb2S3/ CH3NH3PbI3/ CuSCN/Au>.



**Fig. 2.** Variation of photoenergy conversion efficiencies of solar cells during light exposure (AM1.5, 100 mW cm-2) without encapsulation in air for 12 hours: (a) <FTO/TiO2/CH3NH3PbI3/CuSCN/Au>; (b) <FTO/TiO2/Sb2S3/ CH3NH3PbI3/ CuSCN/Au>.



**Fig. 1.** Photo current density-voltage curve of CH3NH3PbI3 perovskite solar cells using CuSCN hole-transporting material.



**Fig. 1.** Photo current density-voltage curve of CH3NH3PbI3 perovskite solar cells using CuSCN hole-transporting material.