Lead-free tin-germanium (SnGe) halide perovskite solar cells with more than 10 % efficiencies

Univ. of Electro-Com[1], Kyushu Inst. Of Tech[2], Ritsumeikan Univ.[3], Univ. of Miyazaki[4], ○Muhammad Akmal Kamarudin[1], Daisuke Hirotani[2], Kengo Hamada[2], Kohei Nishimura[1], Shen Qing[1], Satoshi Iikubo[2], Takashi Minemoto[3], Kenji Yoshino[4], Shuzi Hayase[1]

E-mail: akmal-kamarudin@uec.ac.jp

Lead-free tin perovskite solar cells (PSCs) show the most promise to replace the more toxic lead-based perovskite solar cells. However, the efficiency is significantly less than that of lead-based PSCs as a result of low open-circuit voltage (V_{OC}). This is due to the tendency of Sn^{2+} to oxidize into Sn^{4+} in the presence of air together with the formation of defects and traps caused by the fast crystallization of tin perovskite materials. Here, post-treatment of the tin perovskite layer with edamine Lewis base to suppress the recombination reaction in tin halide PSCs results in efficiencies higher than 10%, which is the highest reported efficiency to date for pure tin halide PSCs. Larger crystal sizes are obtained with EDA post-treatment and the V_{OC} improved by as much as 0.1 V at an optimum EDA concentration. The X-ray photoelectron spectroscopy data suggest that the recombination reaction mainly originates from the nonstoichiometric Sn:I ratio in addition to the large Sn^{4+}:Sn^{2+} ratio. The amine group in edamine bonded to the undercoordinated tin, passivating the dangling bonds and defects, resulting in suppressed charge carrier recombination. Simultaneously, charge carrier injection into electron transport layer has also been improved upon surface passivation with EDA as revealed by transient absorption spectroscopy study. This work provides an evident that the surface recombination also needs to be addressed especially in the case of tin perovskite solar cells in order to achieve better device performance.