高効率プラナー構造のペロブスカイト太陽電池 $CH_3NH_3PbI_{3-x}Cl_x$ における塩素イオンの決定

High Efficiency Planar $CH_3NH_3PbI_{3-x}Cl_x$ based solar cells with determined amount of chloride ion

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In recent years, organometal halide perovskites ($CH_3NH_3PbI_3$) have become a new attractive photovoltaic material due to their remarkable proprieties and impressive power conversion efficiencies. In a very short time, perovskite-based solar cells as it has shown a continuous rise in cell power conversion efficiency, from less than 4% in 2009[1] to over 20% in 2015[2] for both meso- and planar architectures. The principal perovskite layer in meso and planar architecture is usually composed of either pure iodide ($CH_3NH_3PbI_3$) or mixed halide ($CH_3NH_3PbI_{3-x}Cl_x$) perovskite. Chemical formula of $CH_3NH_3PbI_{3-x}Cl_x$ is being typically used for showing that a small amount of chloride salts remains in the device. According to several group chloride ions help in form high quality perovskite film, enhance the coverage, morphology, stability of the final perovskite film and $CH_3NH_3PbI_{3-x}Cl_x$ has been often used to fabricate planar architecture devices with high power conversion efficiency (PCE). In such heterojunction structures the all interfacial connections play an important role in improving the cell performance. We have investigated alternative methods of interface engineering of compact TiO_2 layer, by using $TiCl_4$ and UV(O_3) treatment. $TiCl_4$ and UV(O_3) treatment of the compact TiO_2 layer imparted a positive effect on the cell performance, efficiency improved from 13% to over 17% (Fig.1) by the treatment. Additionally we will discuss about the amount of chloride content in the final product perovskite film. In order to determine the molar ratio of Cl and I in the final perovskite product and to know exact formula of $CH_3NH_3PbI_{3-x}Cl_x$, we employed the ion chromatography method. This method is believed to be a more direct and appropriate method, as compared to indirect estimation from optical properties, XRD, SEM-EDS and XPS analysis.

For analysis we prepared three different perovskite films, then dissolved in deionized water and sulfuric acid and analyzed using ion chromatography method. Considering that all the chloride ions are part of the crystal, the formula can be $CH_3NH_3PbI_{2.94}Cl_{0.06}$. Chloride anions may help in forming high quality iodide perovskite by assisting growth of the final product. In the optimal conditions, we succeeded in fabricating pure iodide perovskite solar cells that exhibited PCE as high as 17.3%.

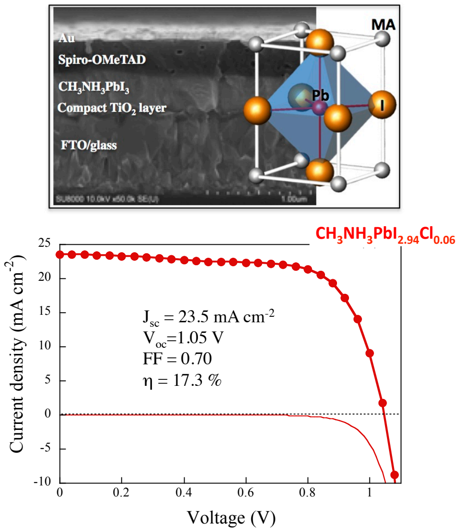

Figure 1. J-V curves of the best performing planar heterojunction perovskite solar cell. [3,4]

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