



Contribution ID: 18

Type: Poster

## Effects of halogen on the properties of $\text{CH}_3\text{NH}_3\text{PbI}_3\text{-yXy}$ layers for perovskite solar cells

Nowadays, solar cells based on  $\text{CH}_3\text{NH}_3\text{PbX}_3$  (when X is halogen) perovskite materials have been intensively studied due to their broad absorption spectrum, long charge carrier lifetime and long carrier diffusion length. However, from previous reports, halogen in perovskite structure typically affects the properties of  $\text{CH}_3\text{NH}_3\text{PbI}_3\text{-yXy}$  active layers in perovskite solar cells. In this study, we then investigated the effects of halogen on the properties of  $\text{CH}_3\text{NH}_3\text{PbI}_3\text{-yXy}$  layers. Perovskite films were prepared by sequential deposition 2-step technique.  $\text{PbI}_2$  or  $\text{PbI}_2\text{-PbCl}_2$  solution was first spin-coated on FTO glasses and subsequently 30 mg/ml of  $\text{CH}_3\text{NH}_3(\text{IxBry})$  solution, with different ratio of I and Br (1:0, 2:1, 4:1, 1:4, 1:2 and 0:1), was coated on top. Then, they were annealed at  $90^\circ\text{C}$  for 1 hour and  $100^\circ\text{C}$  for 25 minutes to transform into perovskite structure. The characterization of perovskite films included X-ray diffraction, UV-Vis spectroscopy, photoluminescence spectroscopy (PL) and Scanning Electron Microscopy. The results indicated that  $\text{CH}_3\text{NH}_3\text{PbI}_3$  have the widest visible light absorption analysis. Having Br and Cl in  $\text{CH}_3\text{NH}_3\text{PbI}_3\text{-xBrx}$  and  $\text{CH}_3\text{NH}_3\text{PbI}_3\text{-x-yBrxCly}$ , respectively, would decrease the absorption in visible light region. However, it could reduce electron and hole recombination as well as increase cell stability, which leads to higher DSSCs' efficiency.

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**Track Classification:** Nanomaterials & nanostructures