Selective Damage of the Hybrid Perovskite Depending on the Electron Beam Direction

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Hybrid perovskite solar cells (PSCs) have shown unprecedented achievements in the solar cell field and, recently, reported high power conversion efficiency (PCE) of 25.7%. Because the performance of the PSCs is strongly related to the crystal structure of the hybrid perovskite, microstructural analysis of the hybrid perovskite using transmission electron microscopy (TEM) is being actively conducted.

The electron beam used in the TEM causes fatal damage to hybrid perovskite. However, there are also several results that the damage is possibly attenuated depending on the irradiation direction of the electron beam. In this report, we will treat the correlation between the degree of electron beam damage and hybrid perovskite crystal orientation.

To examine the above correlation, a $CH_3NH_3PbI_3$ ($MAPbI_3$) single crystal grown by the inverse temperature crystallization method was investigated with TEM observation. TEM specimens were fabricated by the focused ion beam technique (Hitachi NB5000), and the TEM observation was performed at 300 keV using Hitachi HF-3300. During the TEM observation, the electron beam irradiation conditions were carefully controlled to exclude unintended additional electron beam damage.

From the TEM observation of the correlation, we confirmed that there is a direction selectivity of the electron beam damage when the electron beams are irradiated to the $MAPbI_3$ single crystal. According to the results, the $[00\bar{1}]$ direction is more vulnerable to electron beam damage caused by radiolysis and knock-on than the $[\bar{1}1\bar{1}]$ direction in the $MAPbI_3$ single crystal. Figure 1. is the atomic configuration diagram showing the results schematically.

This research has been supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (2021R1I1A3054561).

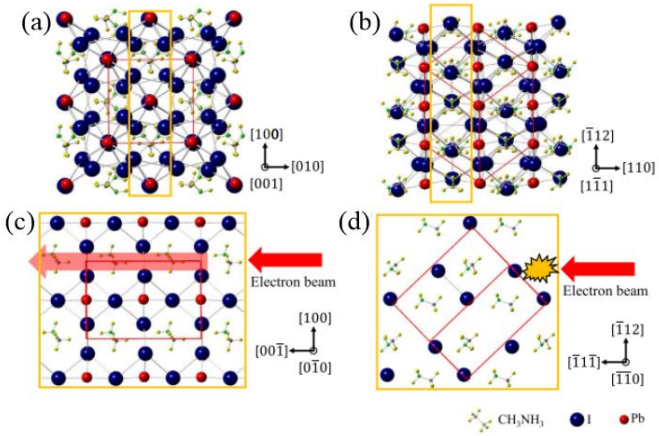

Fig. 1. Atomic configurations of a $MAPbI_3$ crystal structure observed along (a) $[00\bar{1}]$ and (b) $[\bar{1}1\bar{1}]$. Schematic diagrams that the electron beam is (c) directed to the CH_3NH_3 and (d) stopped by the I atom.

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