Air and vacuum exposure of 3D and quasi-2D perovskites

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2D/3D (a thin layer of 2D perovskite formed on top of 3D perovskite) and quasi-2D (introducing a large organic cation into the 3D perovskite) perovskites have attracted considerable attention since it can be a potential candidate to enhance the lifetime of the perovskite solar cells.[1-2] In this regard, surface properties of 3D and quasi-2D perovskites are paramount important for improving solar cell performance. Therefore, it is crucial to examine the surface structure used an efficient experimental way.

Recently we examined surface termination of solution processed $MAPbI_3$ film using ultraviolet photoelectron (UPS) and metastable-atom electron (MAES) spectroscopies.[3] We also demonstrated that the large organic cation PEA covers the surface of quasi-2D $PEA_2MA_{n-1}Pb_nI_{3n+1}$ perovskite using the same method of UPS and MAES.[4] UPS examines the valence electronic states of materials based on the photoemission excited by ultraviolet photons. In MAES, excitation source is replaced with metastable He atom. MAES selectively sensitive to the outermost surface atoms because the metastable atoms do not penetrate into the inner layers.[5] Therefore, combination of the UPS and MAES enables us to obtain the information about the outermost surface.

In this work we investigated the effect of air and vacuum exposure of both pristine 3D and quasi-2D $PEA_2MA_{n-1}Pb_nI_{3n+1}$ perovskite using the same method of UPS and MAES spectroscopies. Figure 1 displays the UPS spectra of 3D $MAPbI_3$ and quasi-2D perovskites before and after exposed to air for one day. From the UPS spectra of 3D $MAPbI_3$, we observed that peaks at 4.7, 5.4 and 10.9 eV disappeared and found only one broad peak after 1-day exposure. That means surface of the 3D perovskite was already contaminated by air. In the case of quasi-2D perovskite, shapes of the spectra and peak positions didn't change after 1-day exposure.

From the combination of UPS and MAES spectra, we found that 3D perovskite degraded to PbI_2, and the surface of the quasi-2D perovskite, on the other hand, remain unchanged before and after vacuum/air exposure. The results strongly demonstrated that after the 3D perovskite surface covered with a thin PEA based 2D perovskite (quasi-2D), degradation is ceased in both vacuum and air.

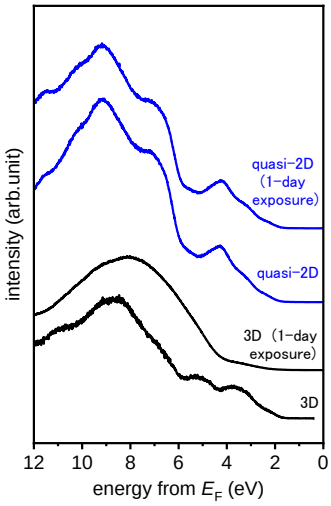

Figure 1. UPS spectra of 3D (black) and quasi-2D (blue) perovskite before and after exposed to air for one day.

References

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