Large-Area 2D Heterostructures of Perovskite and WS_2

[1]Kyushu Univ., [2]Kyoto Univ., [3]AIST, [4]Univ. Tsukuba

Ufuk Erkılıç,[1] Hyungoo Ji,[1] Pablo Solís-Fernández,[1] Keisuke Shinokita,[2] Yung-Chang Lin,[3] Kazu Suenaga,[3] Susumu Okada,[4] Kazunari Matsuda,[2] Hiroki Ago[1]

E-mail: h-ago@gic.kyushu-u.ac.jp

Recently, hybrid organic-inorganic perovskites have attracted great attention in photovoltaic applications due to their exceptional properties, such as high optical absorption, strong luminescence, and tunable bandgap.[1] Thus, heterostructures of perovskites with other 2D materials can offer exciting new phenomena and expand the properties of the constituents. However, because of their solubility in common solvents conventional lithography and transfer techniques are not applicable to perovskites to realize complicated heterostructures.[2] Here, by using tungsten disulfide (WS_2) as an effective template and strictly controlling the deposition conditions, we demonstrate the selective and epitaxial growth of 2D lead iodide (PbI_2) on monolayer WS_2 and successive vapor-phase conversion to 2D perovskite/WS_2 heterostructure.

Monolayer WS_2 grown by chemical vapor deposition (CVD) on c-plane sapphire was utilized to deposit PbI_2 by vapor phase deposition. Then, the intercalation of methyl ammonium (MA) was performed to convert the top PbI_2 layer to organic-inorganic perovskite ($MAPbI_3$), as illustrated in Fig. 1a. Figure 1b shows microscope images of WS_2 grains before and after the deposition of the perovskite, indicating selective growth of the perovskite on WS_2 due to different surface energies of WS_2 and sapphire. AFM image (Fig. 1c) displays a perovskite with uniform thickness (3~4 nm) almost covering the triangular WS_2 grain. We observed moiré patterns by STEM observation as a result of lattice mismatch between two materials. From the PL life time measurement (Fig. 1d), we found there is strong electric coupling between the perovskite and WS_2. Taking the advantage of selective growth, we demonstrated large-area photodetectors using micro-patterned perovskite/WS_2 heterostructure. We believe that using 2D materials as a template for perovskite growth may facilitate advance device applications of perovskites beyond spin-coated solar cells.

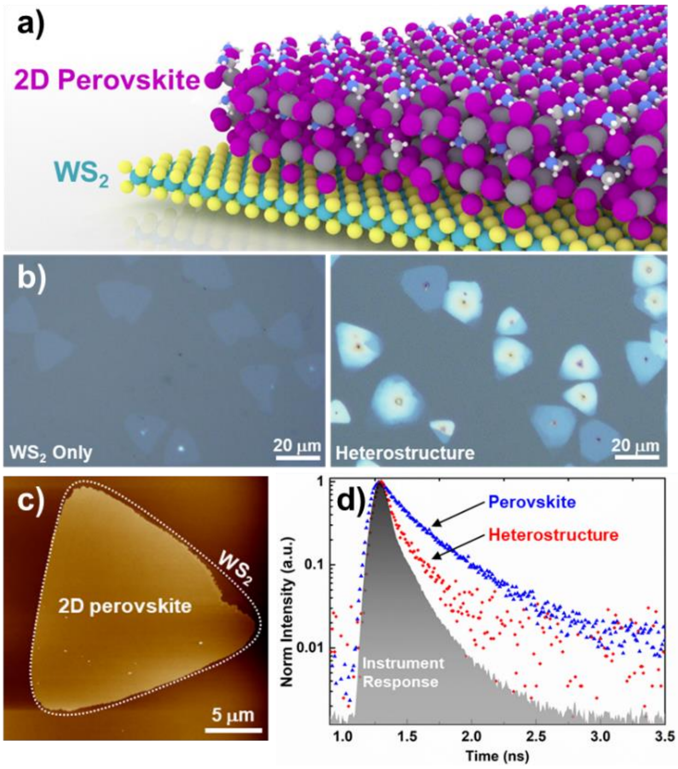

Figure 1. (a) Schematic illustration of heterostructure. (b) Optical images of WS_2 grains before and after perovskite deposition. (c) AFM images of heterostructure. (d) PL decay profiles of perovskite and heterostructure.

References:

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