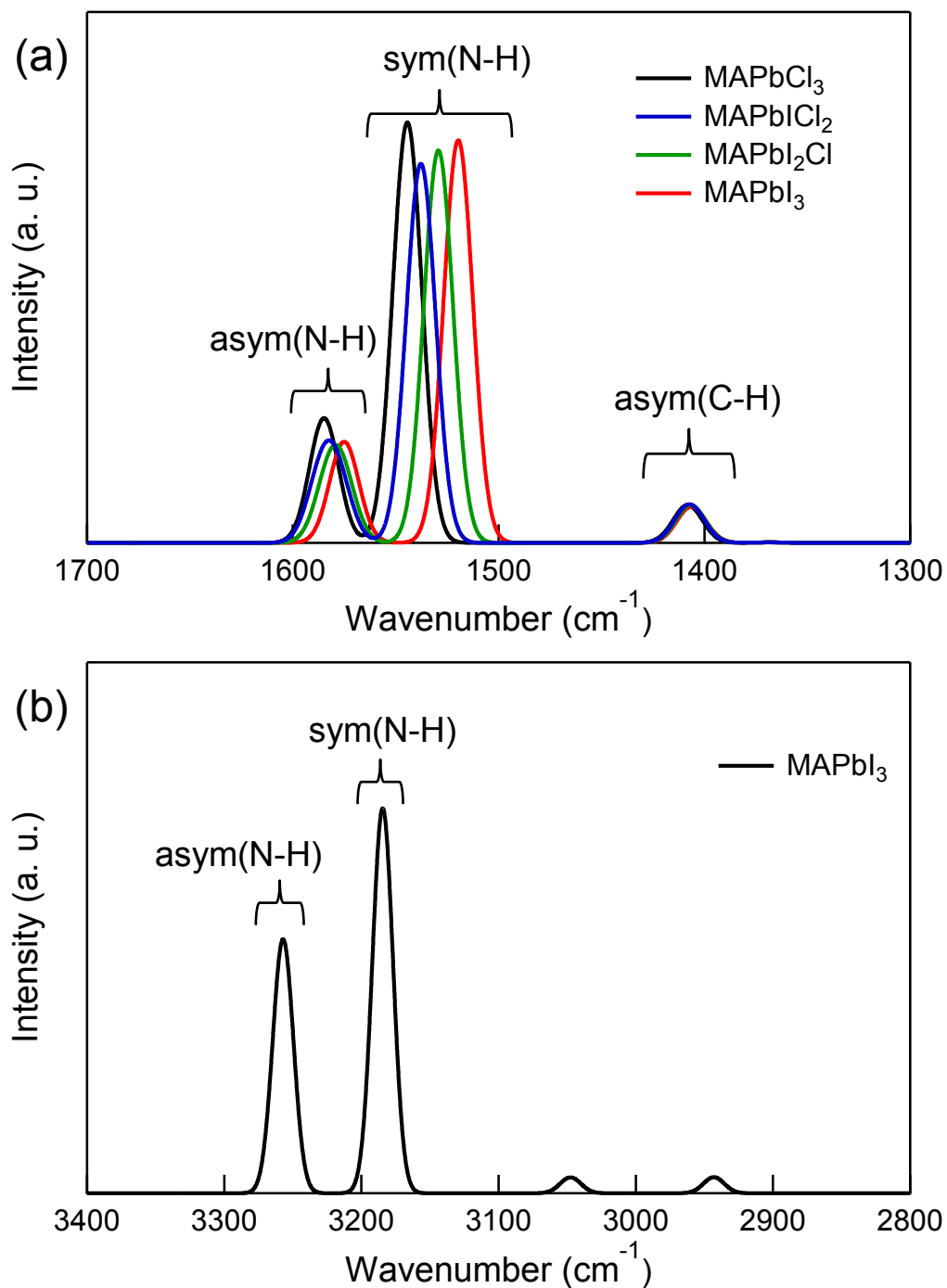
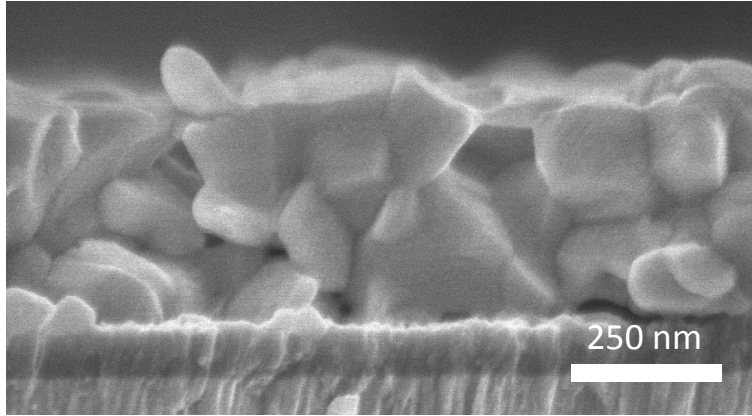


## SUPPLEMENTAL INFORMATION



**Figure S1.** The simulated absorption spectra of MAPbCl<sub>3</sub>, MAPbICl<sub>2</sub>, MAPbI<sub>2</sub>Cl, and MAPbI<sub>3</sub> at low frequency region (a) and simulated absorption spectra of MAPbI<sub>3</sub> at high frequency region.



**Figure S2.** Cross-sectional SEM images of the TI perovskite layer annealed for 15 minutes.