

Figure S1. Original XPS spectra for perovskite films with different compositions.

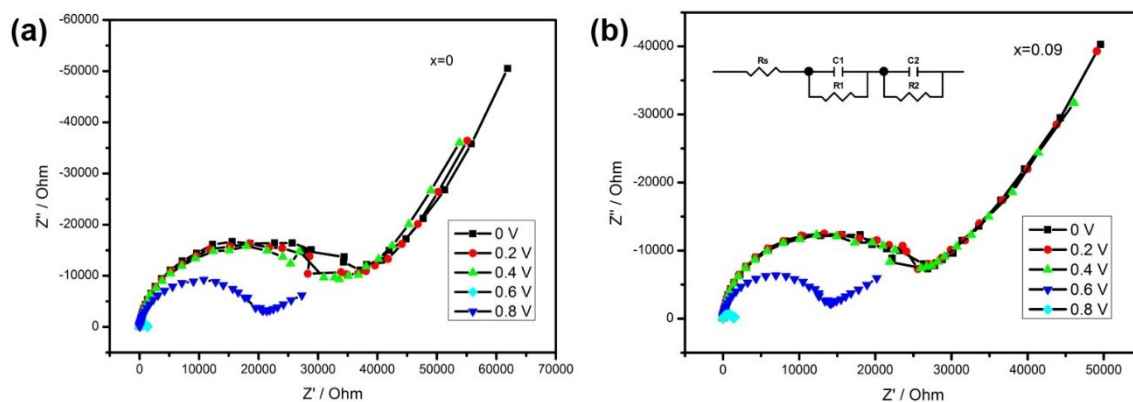


Figure S2. (a) impedance spectra of perovskite solar cells with MAPbI<sub>3</sub> (a) and Cs<sub>0.09</sub>MA<sub>0.91</sub>PbI<sub>3</sub> (b) as absorbers. the equivalent circuit for fitting was shown in the inset.

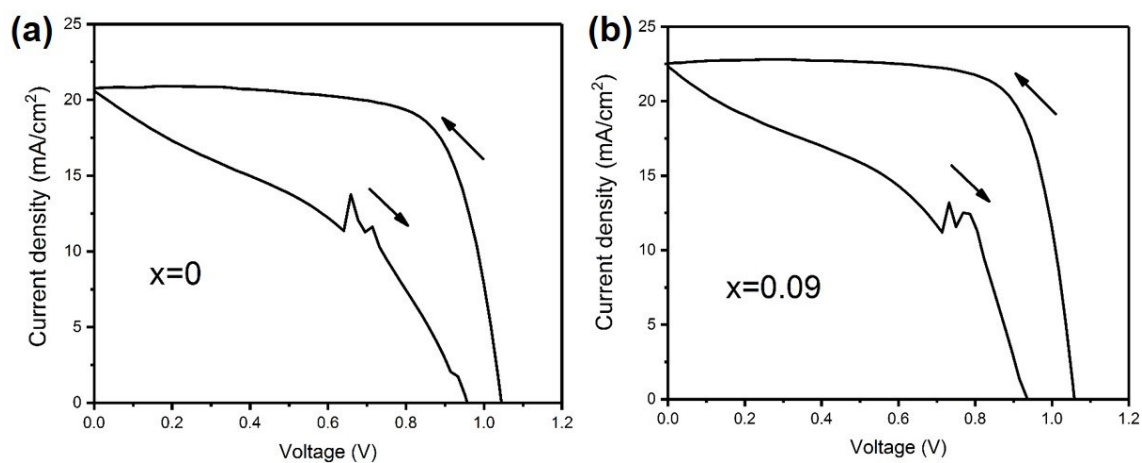


Figure S3. Hysteresis effect of perovskite solar cells with MAPbI<sub>3</sub> (a) and Cs<sub>0.09</sub>MA<sub>0.91</sub>PbI<sub>3</sub> (b) as absorbers.