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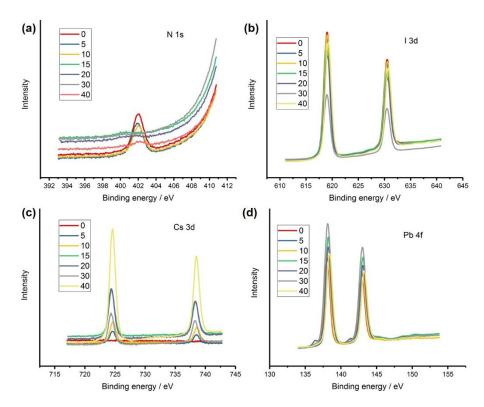


Figure S1. Original XPS spectra for perovskite films with different compositions.

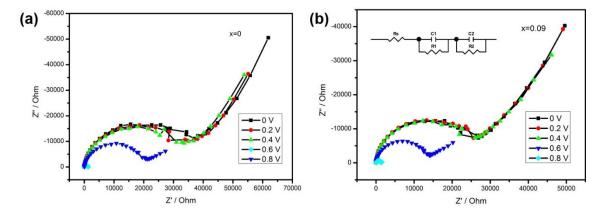


Figure S2. (a) impedance spectra of perovskite solar cells with $MAPbI_3$ (a) and $Cs_{0.09}MA_{0.91}PbI_3$ (b) as absorbers. the equivalent circuit for fitting was shown in the inset.

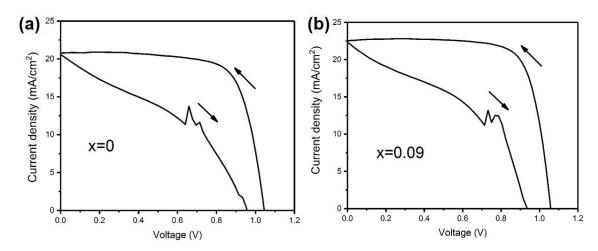


Figure S3. Hysteresis effect of perovskite solar cells with MAPbI₃ (a) and $Cs_{0.09}MA_{0.91}PbI_3$ (b) as absorbers.