

Supporting Information

Preparation of Nickel Oxide Nanoflakes for Carrier Extraction and Transport in Perovskite Solar Cells

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Table S1. Lifetime parameters of TR-PL curves of the perovskite on the FTO substrate, PTAA, NiO_x thin film/PTAA, and NiO_x nanoflakes/PTAA.

Substrate	A ₁ (%)	τ_1 (ns)	A ₂ (%)	τ_2 (ns)	τ_{avg} (ns)
FTO	54.9	10.56	45.3	147.13	139.5
PTAA	50.69	16.07	49.31	103.02	91
NiO _x thin film/PTAA	51.29	16.51	48.71	83.9	72.34
NiO _x nanoflakes/PTAA	55.61	13.95	44.39	64.04	53.3

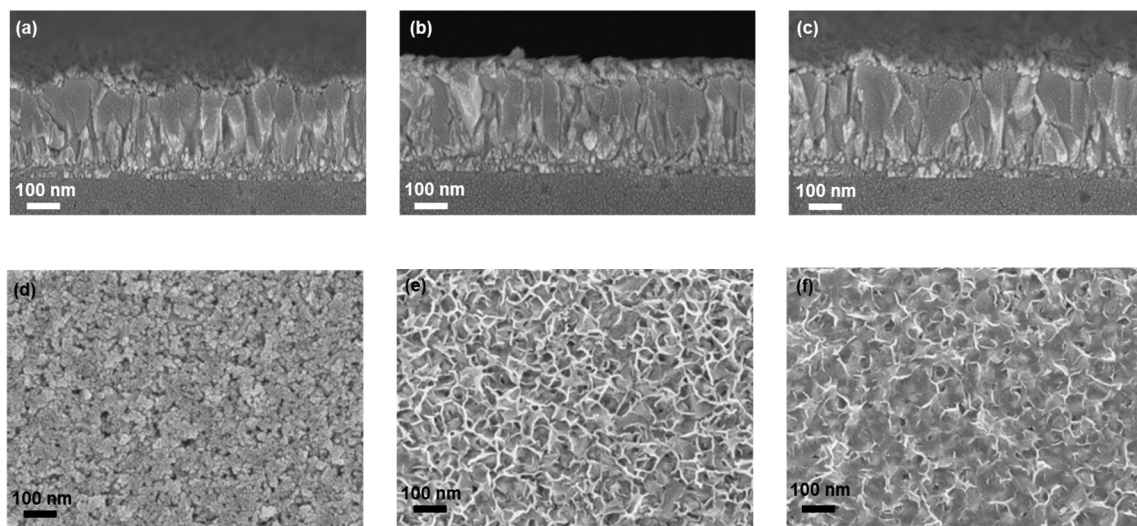


Figure S1. Cross-sectional and top-view SEM images of (a,d) ZnO nanorods, (b,e) mesoporous NiO_x before ZnO etching, and (c,f) NiO_x nanoflakes after ZnO etching.

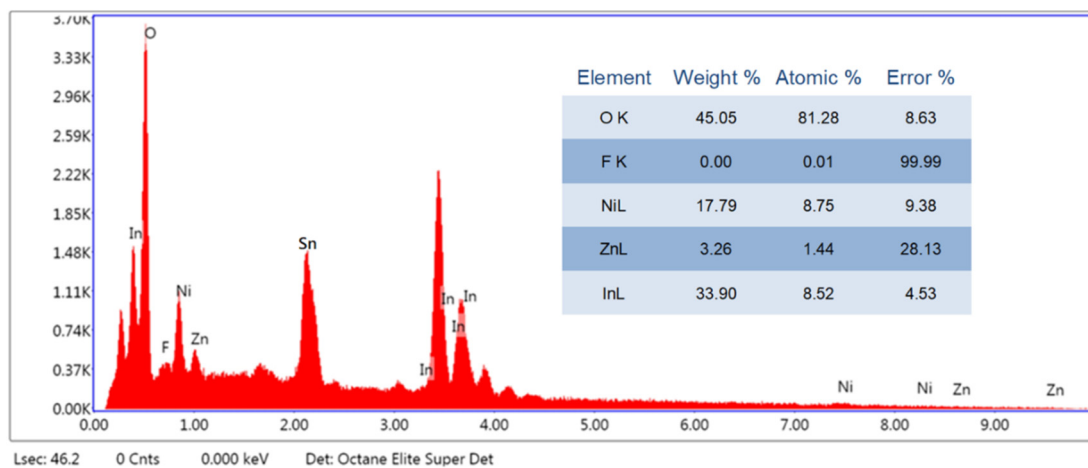


Figure S2. EDS spectrum of the NiO_x nanoflakes.

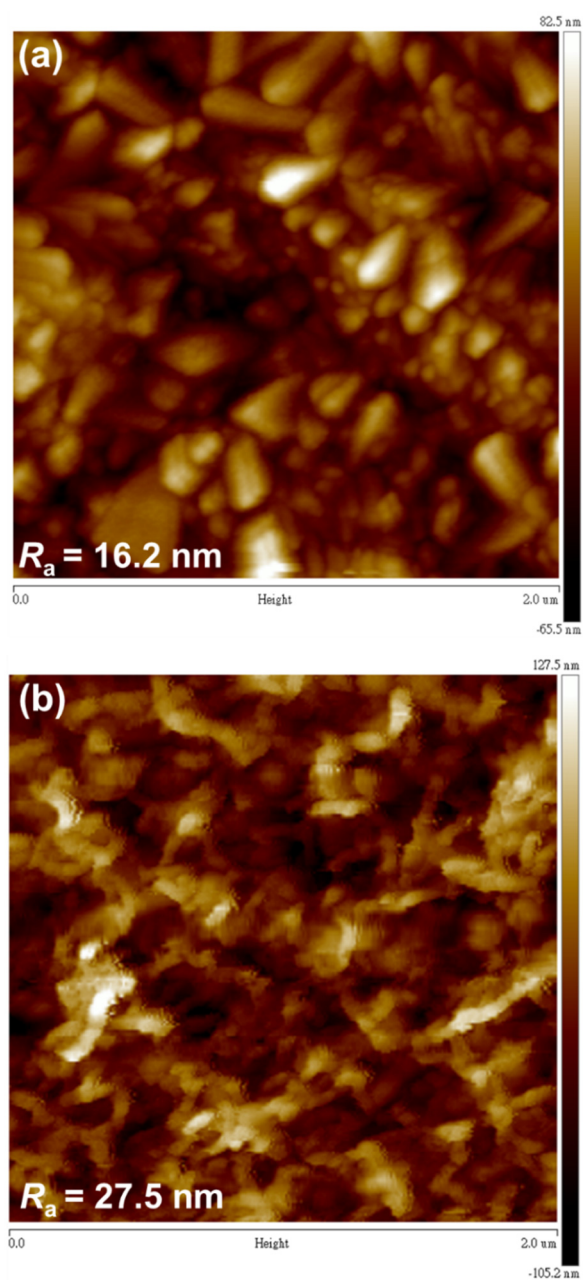


Figure S3. AFM topographic images of the NiO_x (a) thin film and (b) nanoflakes.

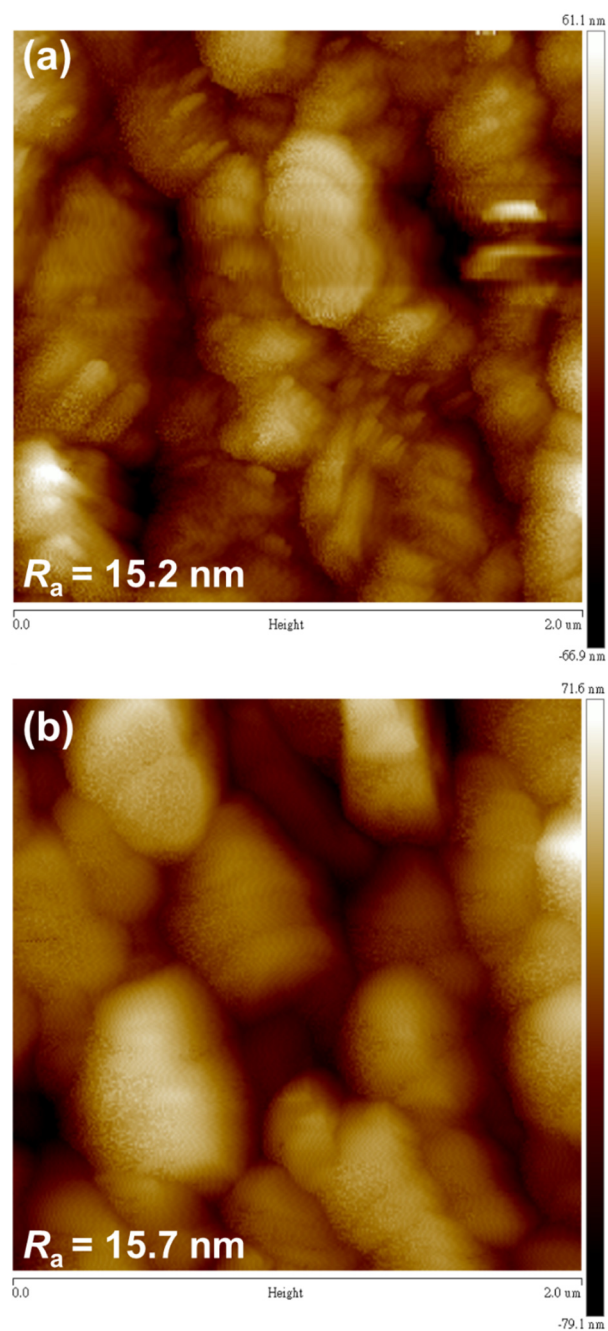


Figure S4. AFM topographic images of the perovskite on the (a) NiO_x thin film/PTAA and (b) NiO_x nanoflakes/PTAA.

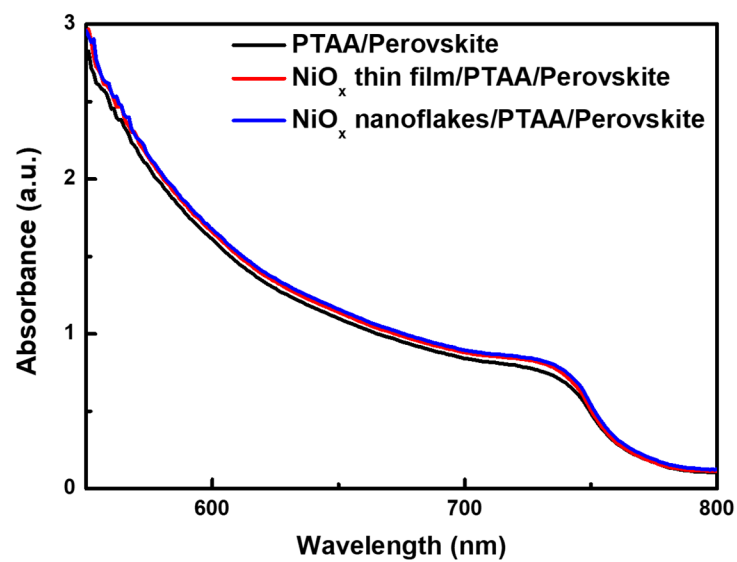
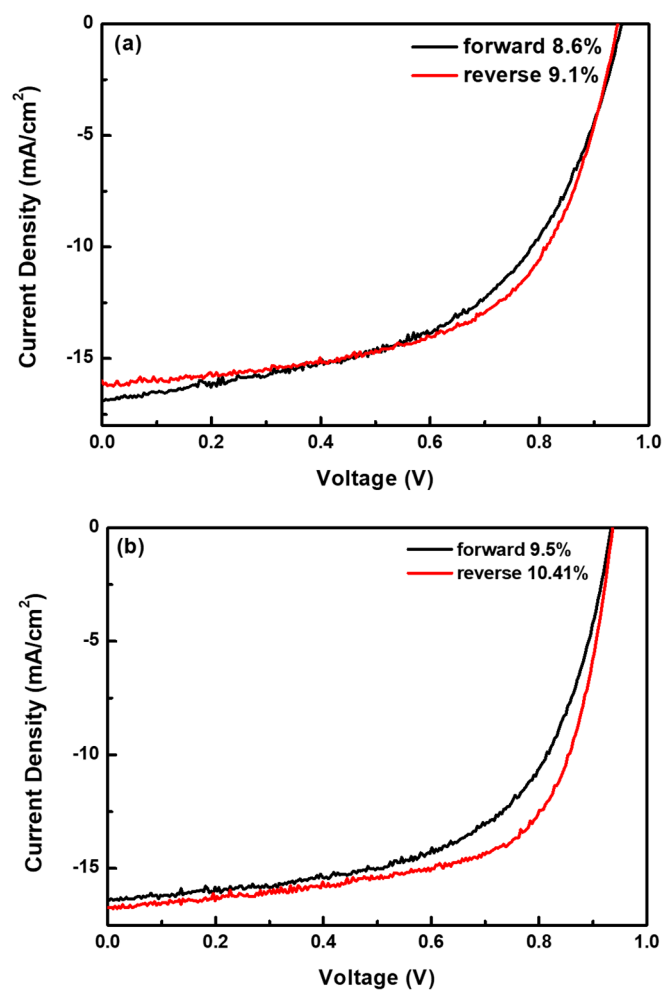


Figure S5. Absorption spectra of the perovskite on PTAA, NiO_x thin film/PTAA, and NiO_x nanoflakes/PTAA.



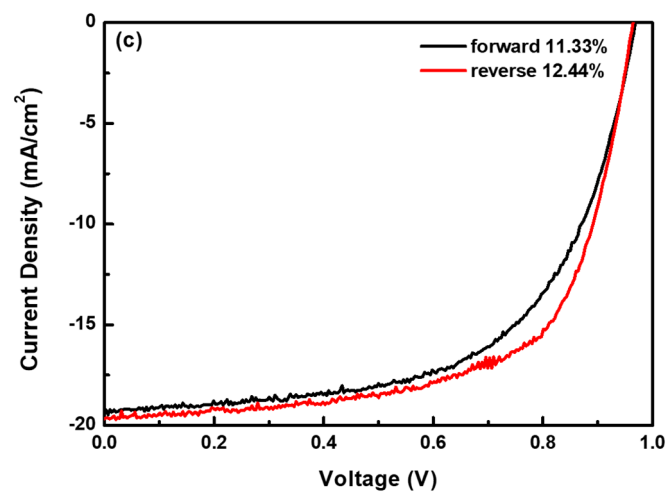


Figure S6. J-V characteristics and PCE values of the devices using (a) PTAA, (b) NiO_x thin film, and (c) NiO_x nanoflakes as the HTL.

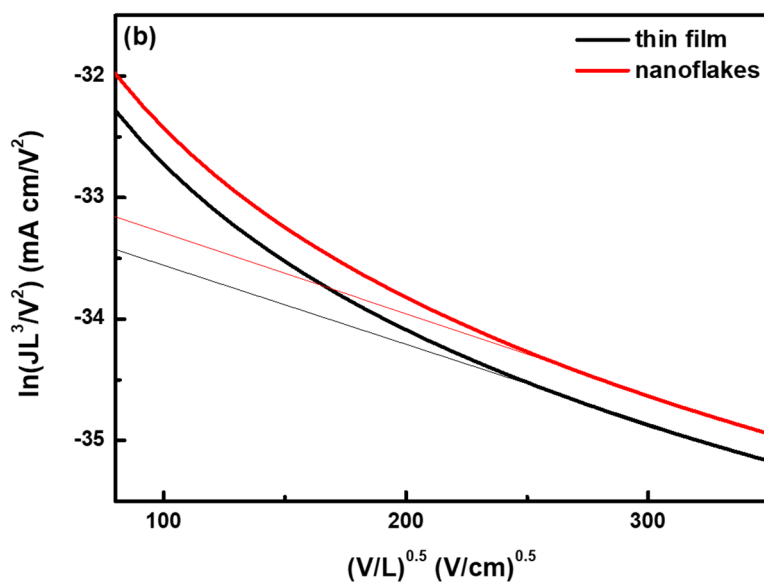
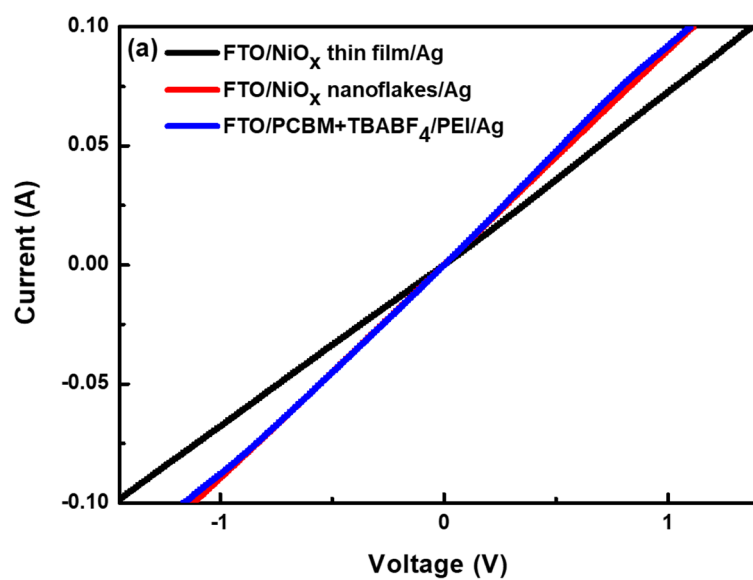


Figure S7. (a) Current–voltage characteristics of hole-only devices FTO/NiO_x thin film or nanoflakes/Ag and electron-only device FTO/PCBM+TBABF₄/PEI/Ag; (b) hole mobility of the NiO_x thin film or nanoflakes versus electric field (V/L)^{0.5}.

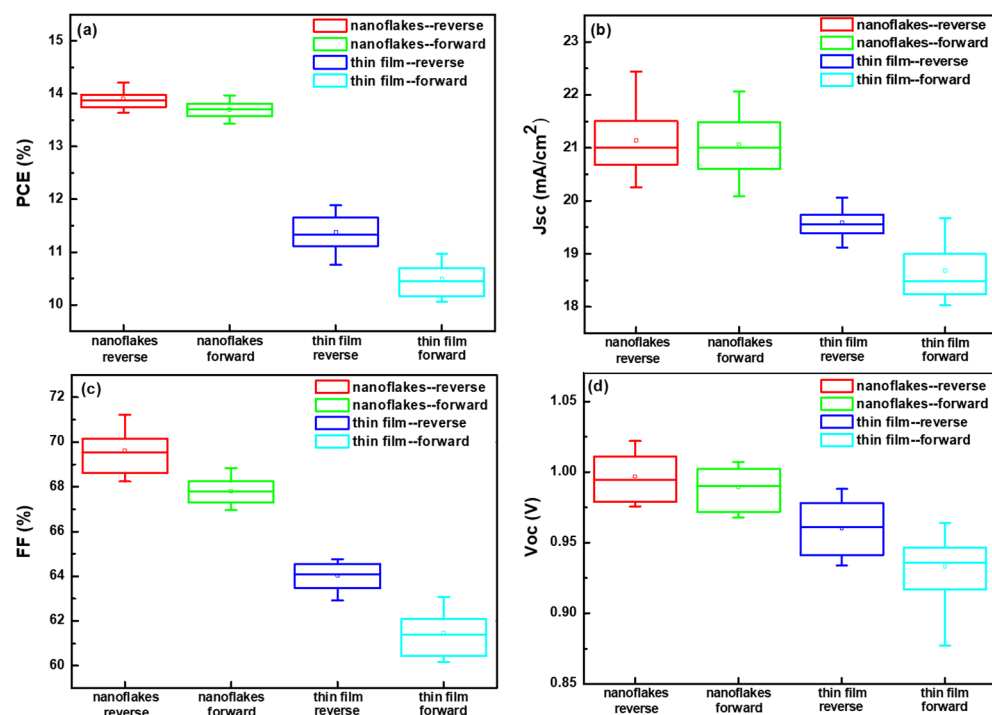


Figure S8. Performance variation represented as a standard box plot in (a) PCE, (b) J_{sc}, (c) FF, and (d) V_{oc} from 20 devices based on the NiO_x thin film and nanoflakes in the forward and reverse scans.