Supporting Information

Dynamic halide perovskite heterojunction generates direct current

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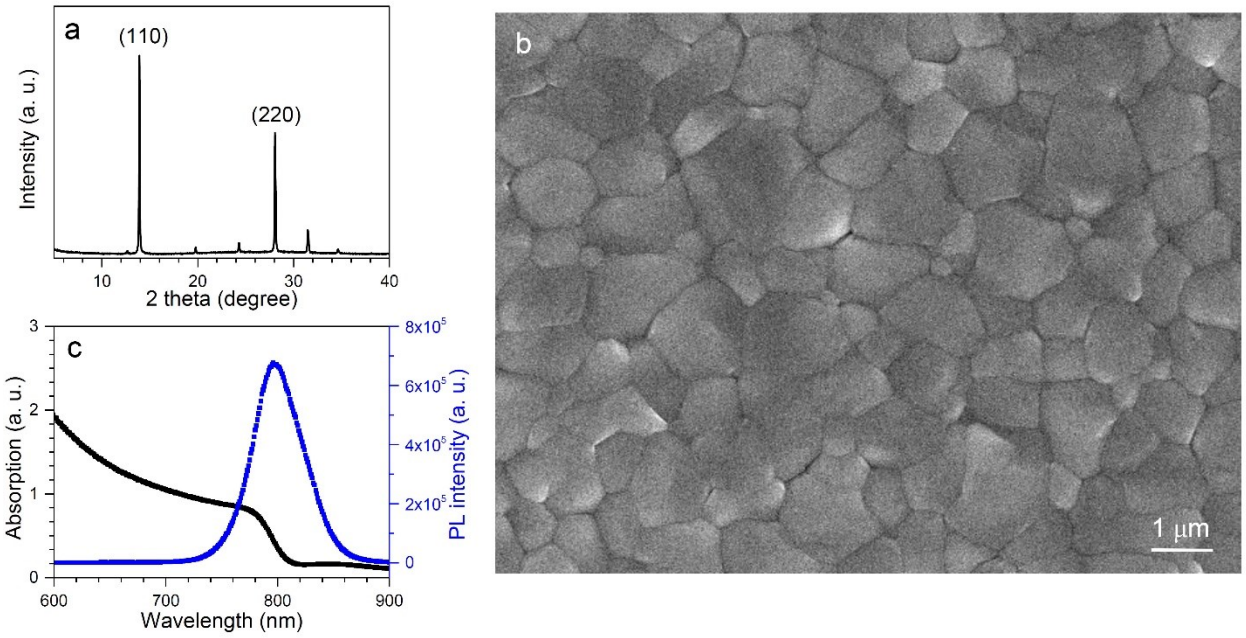

Figure S1. (a) XRD, (b) SEM, and (c) absorption and PL spectrum of $FAPbI_3$ perovskite film. XRD, PL, and absorption samples were prepared on glass substrates. The SEM sample was prepared on FTO conductive substrate.

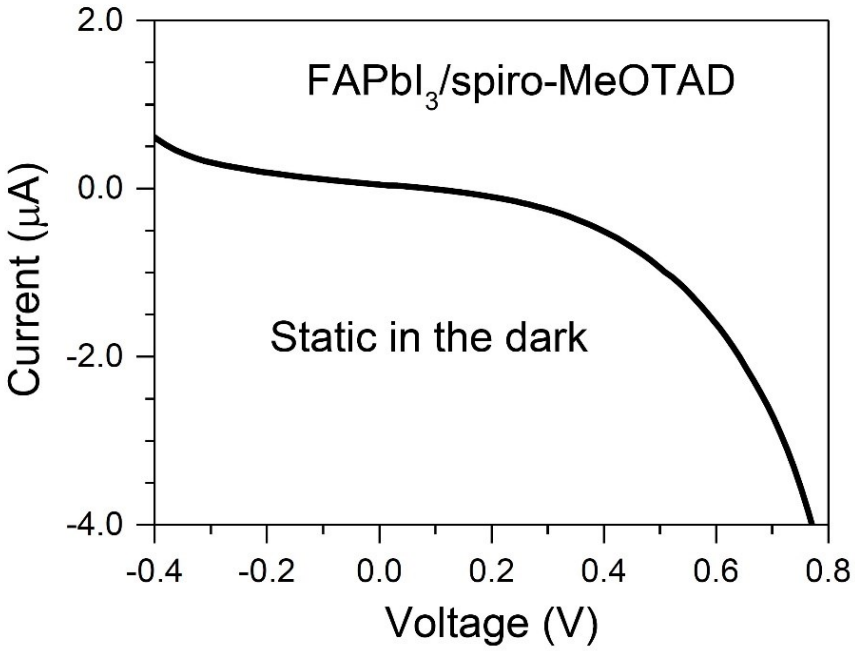

Figure S2. IV curve of the static $FAPbI_3$/Spiro heterojunction by pressing the spiro-coated electrode on the $FAPbI_3$-coated electrode.

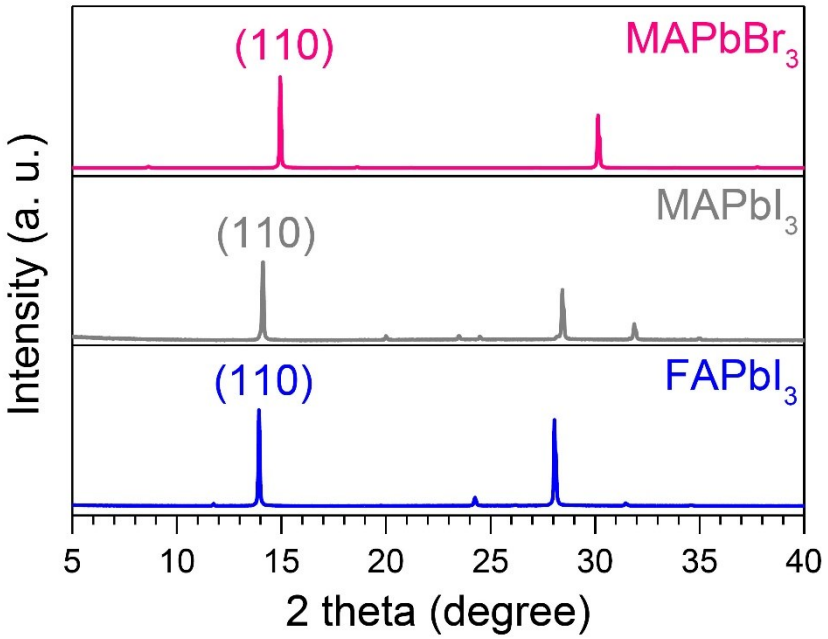

Figure S3. XRD results of $FAPbI_3$, $MAPbI_3$ and $MAPbBr_3$ films on glass substrate.

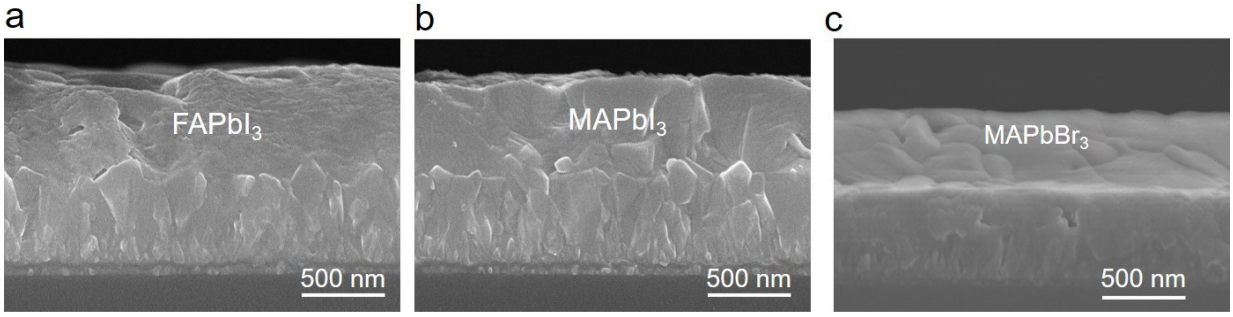

Figure S4. Cross-sectional SEM images of $FAPbI_3$, $MAPbI_3$ and $MAPbBr_3$ on FTO substrate.

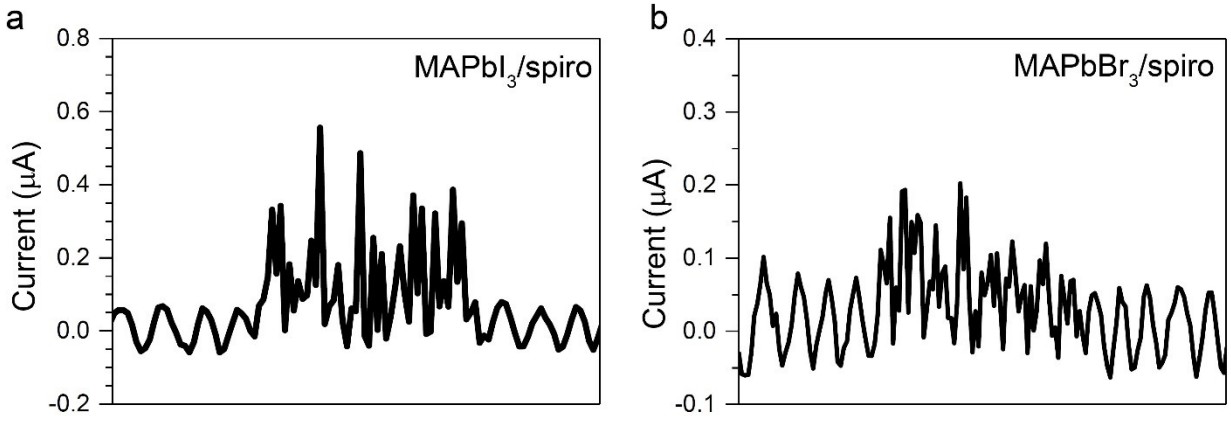

Figure S5. Current performance of (a) the $MAPbI_3$/spiro and (b) the $MAPbBr_3$/spiro heterojunction by pressing and sliding the spiro-coated electrode on the $MAPbX_3$ (X= I or Br)-coated electrode. The applied force was ~5 N and contact area was ~1 cm^2.

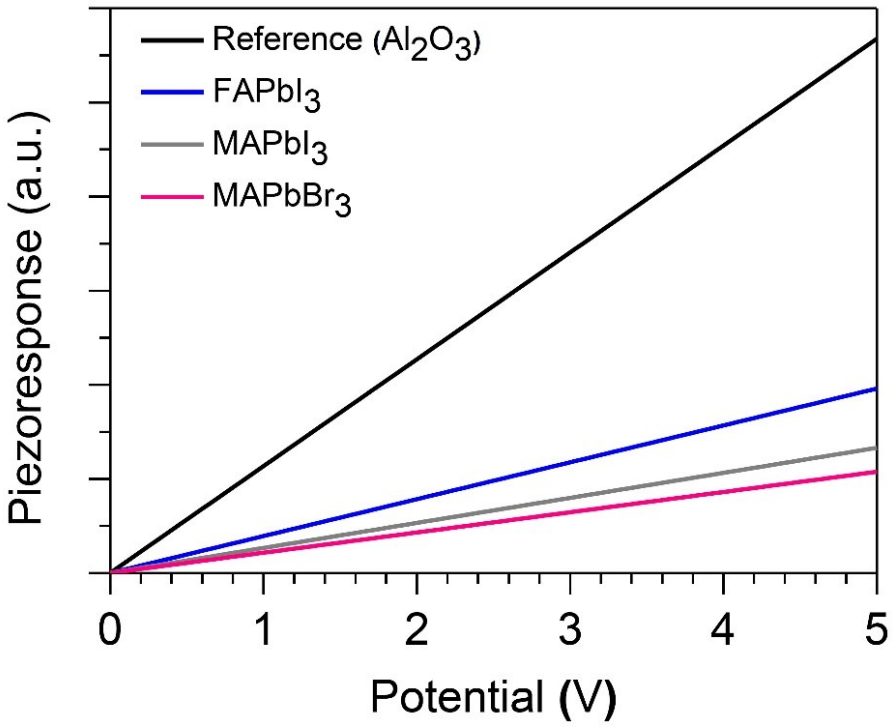

Figure S6. Piezoresponse of $FAPbI_3$, $MAPbI_3$ and $MAPbBr_3$. Al_2O_3 was measure as reference. These samples were prepared on FTO conductive substrate and piezoresponse in d_{33} direction of each perovskite sample was measured by piezoresponse force microscopy (PFM).

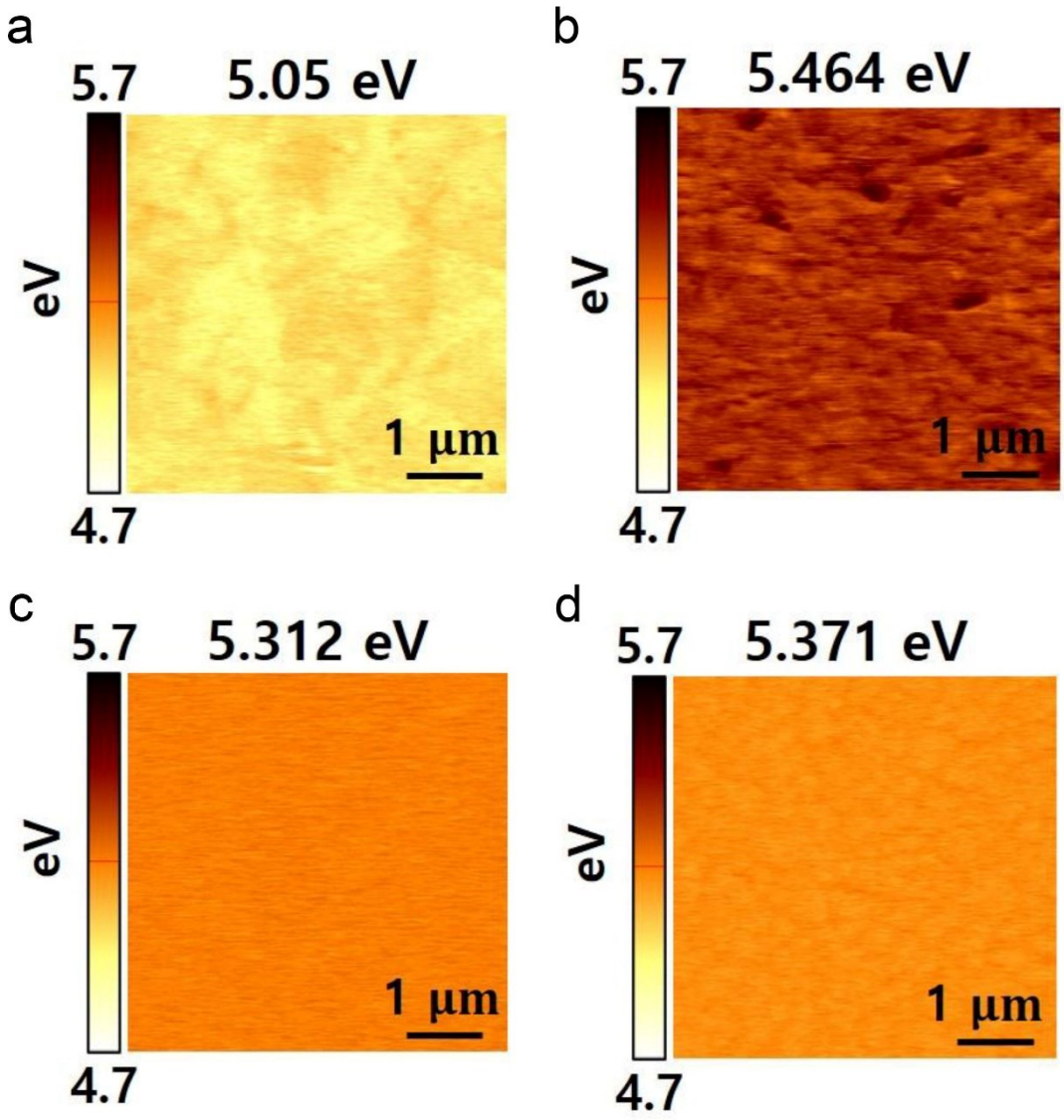

Figure S7. KPFM of (a) $FAPbI_3$, (b) $MAPbI_3$, (c) $MAPbBr_3$, and (d) spiro. These samples were prepared on FTO conductive substrate.

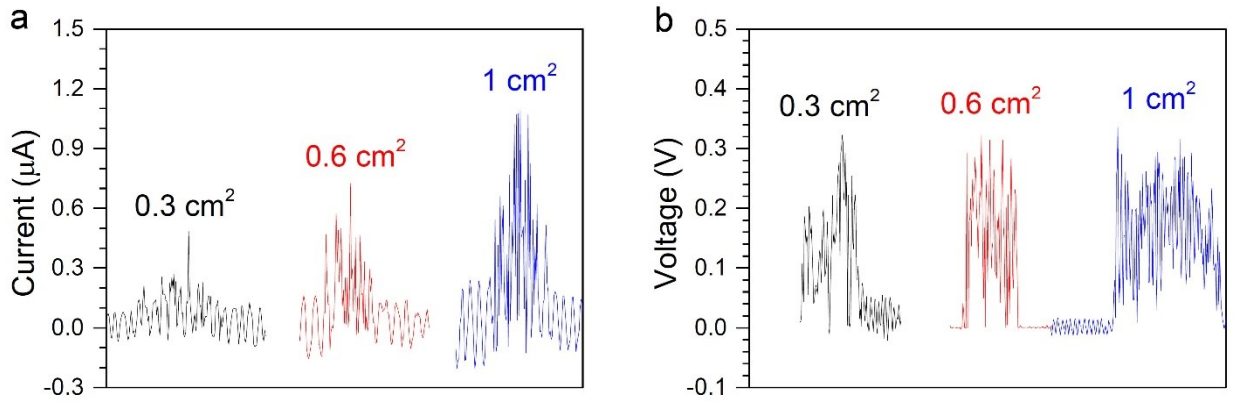

Figure S8. Current and voltage output change versus area on the dynamic $FAPbI_3$/spiro heterojunction by pressing and sliding the spiro-coated electrode on the $FAPbI_3$-coated electrode. The applied force is ~5 N.

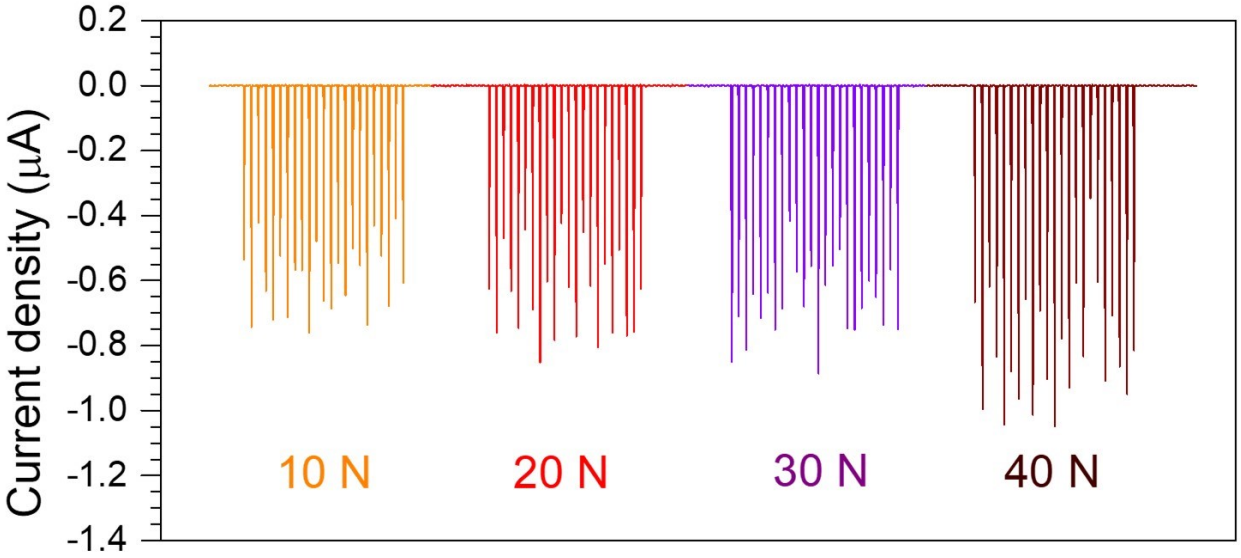

Figure S9. Dependence of current output on applied force on the dynamic $FAPbI_3$/spiro heterojunction. The contact area was ~0.5 cm^2.

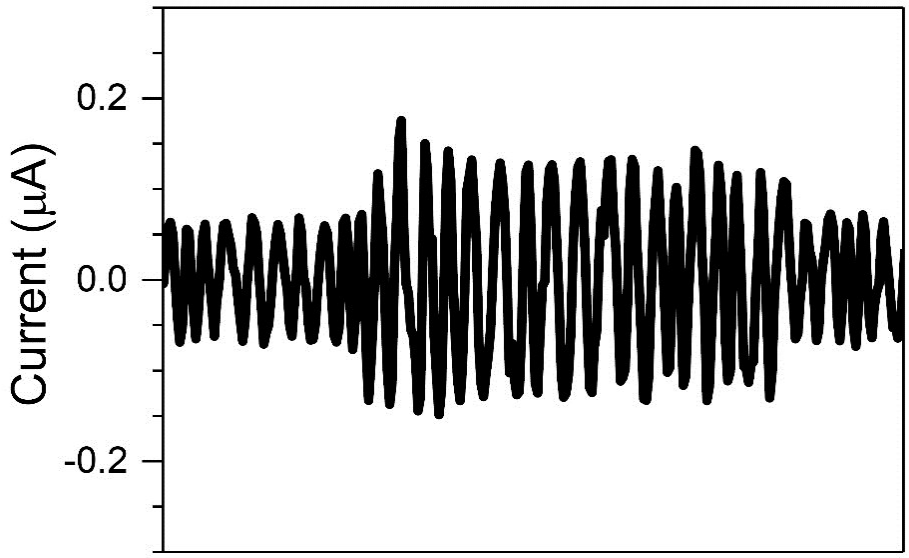

Figure S10. Current output performance of the PEA_2PbI_4/spiro heterojunction by pressing and sliding the spiro-coated electrode on the PEA_2PbI_4-coated electrode. The contact area is ~1 cm^2 and the applied force is ~5 N.

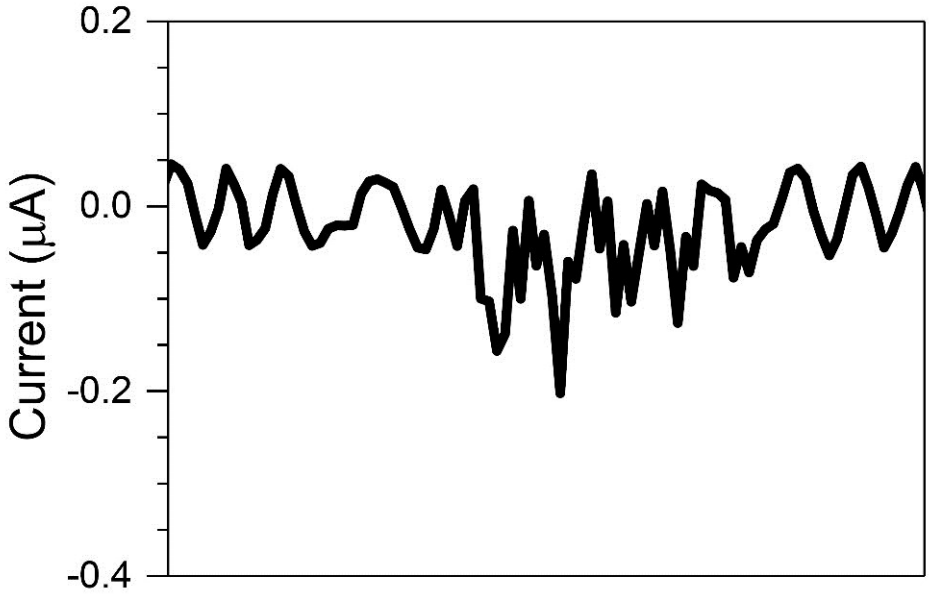

Figure S11. Current performance of the perovskite/TiO_2 heterojunction by pressing and sliding the TiO_2-coated electrode on the perovskite-coated electrode. The contact area is ~1 cm^2 and the applied force is ~5 N.

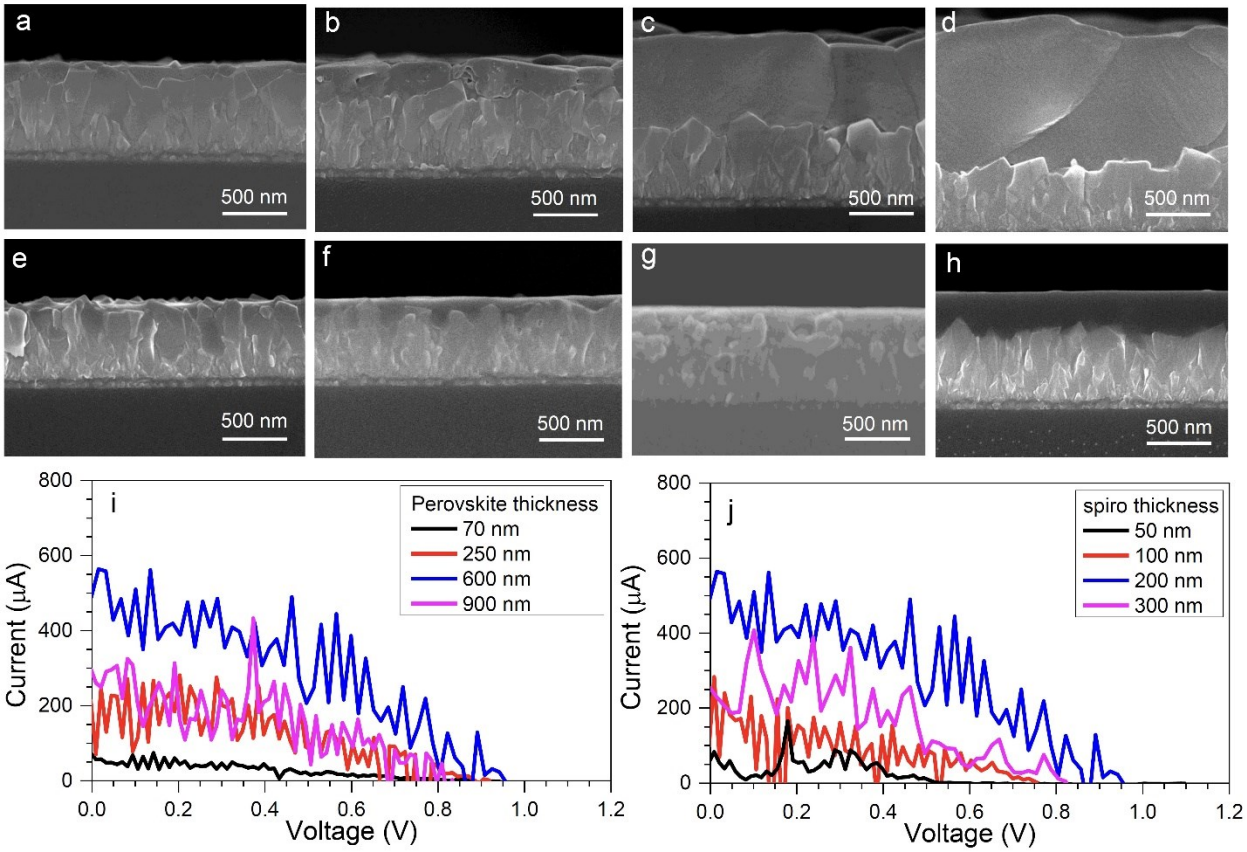

Figure S12. Influence of the thickness of perovskite film and spiro film on the triboelectric and photovoltaic coupling performance. Cross-sectional SEM images of perovskite films with thicknesses of (a) 70 nm, (b) 250 nm, (c) 600 nm, (d) 900 nm and spiro films with thicknesses of (e) 50 nm, (f) 100 nm, (g) 200 nm, (h) 300 nm. IV curves of the devices with different thicknesses of (i) perovskite films and (j) spiro films. The contact area was ~1 cm^2 and the applied force was ~5 N.

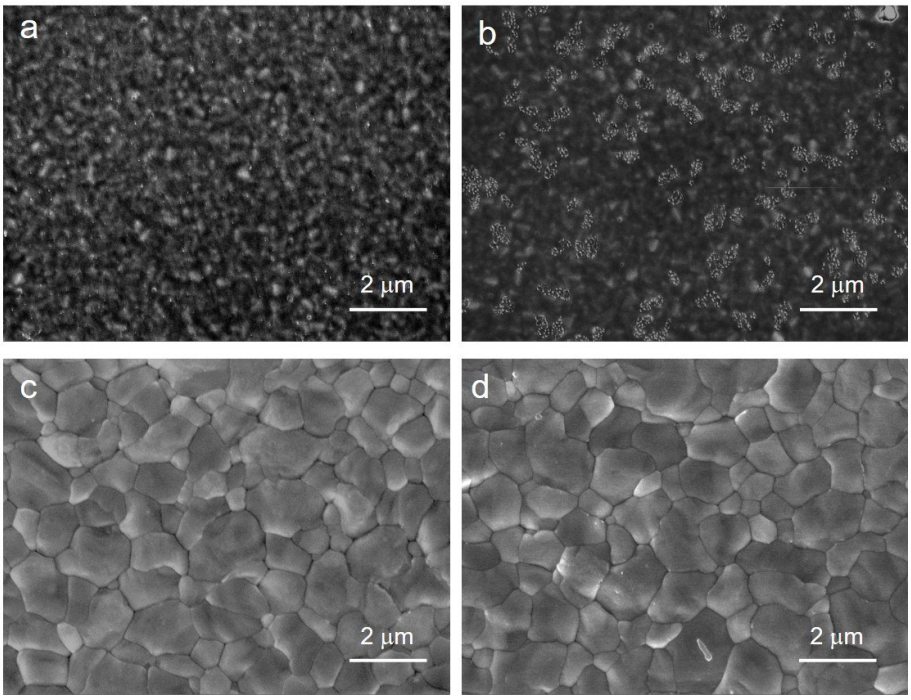

Figure S13. SEM images of (a, b) spiro and (c, d) perovskite films, where (a) and (c) are corresponding to the pristine spiro and perovskite films, respectively, and (b) and (d) for the spiro and perovskite films after 20 cycles under applied force of 40 N.

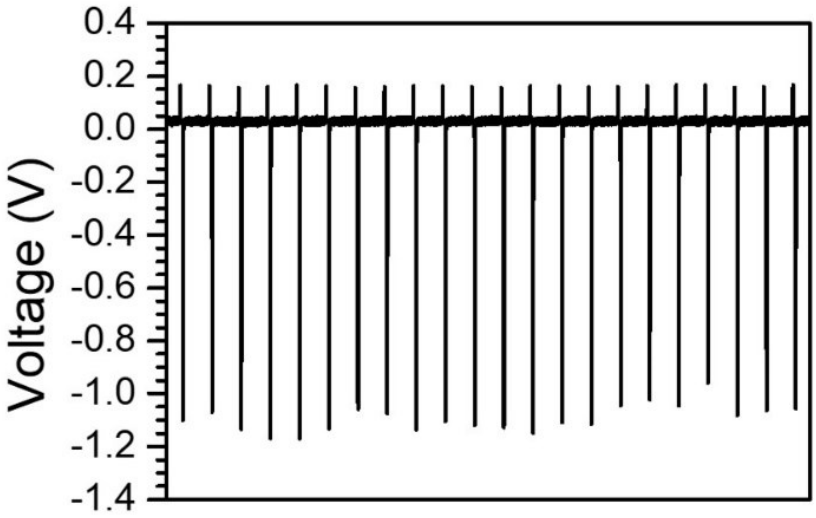

Figure S14. Voltage performance of the dynamic $FAPbI_3$/spiro heterojunction for 22 cycles under applied force of 40 N.

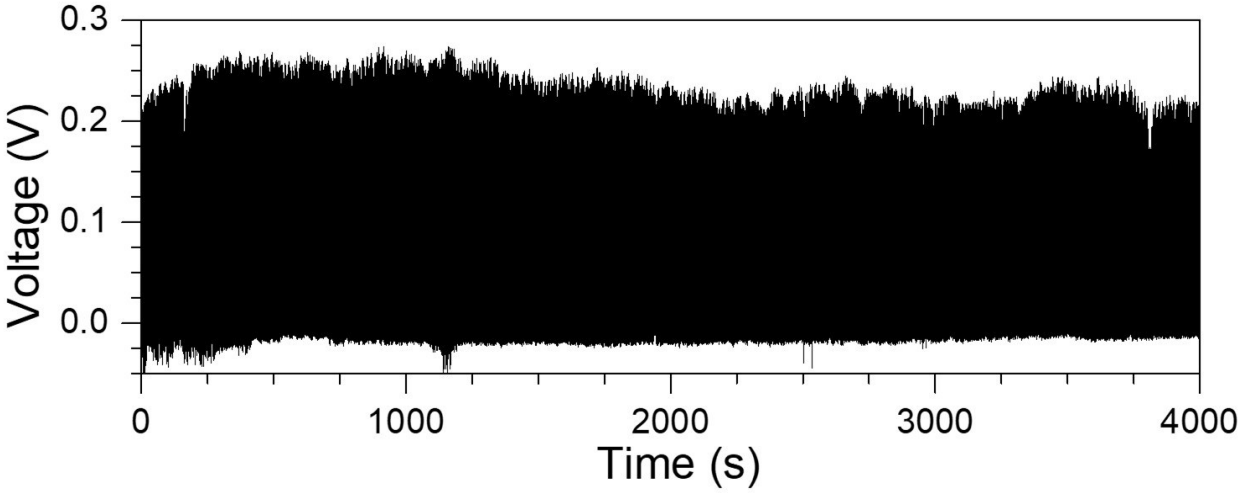

Figure S15. Voltage endurance performance of the dynamic $FAPbI_3$/spiro heterojunction under continuous sliding for 4000 s. The area was ~1cm^2.

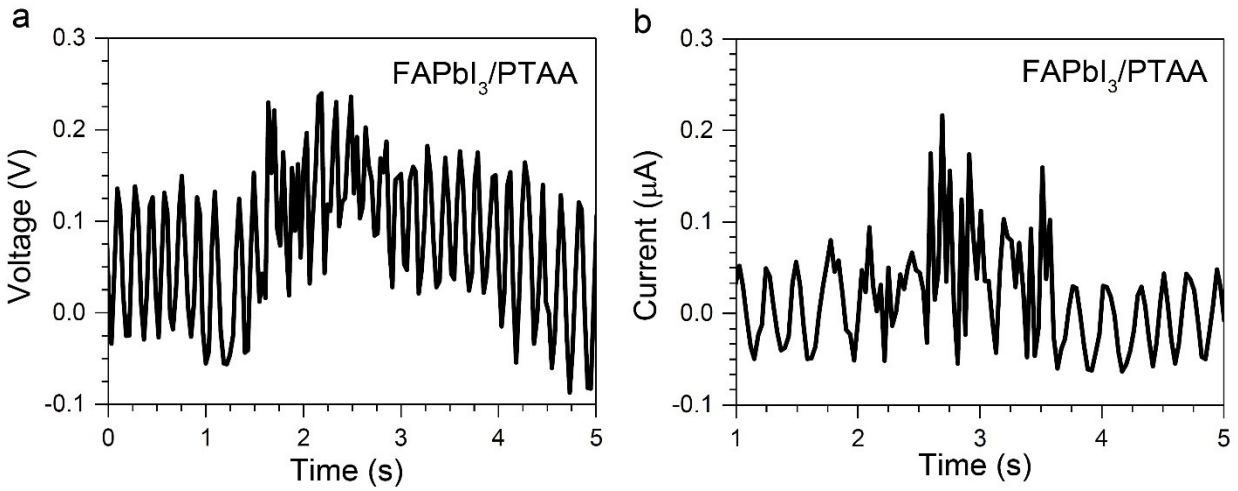

Figure S16. (a) Voltage and (b) current performance of the dynamic $FAPbI_3$/PTAA heterojunction by pressing and sliding the PTAA-coated electrode on the $FAPbI_3$-coated electrode. The applied force was ~5 N and the contact area was ~1 cm^2.

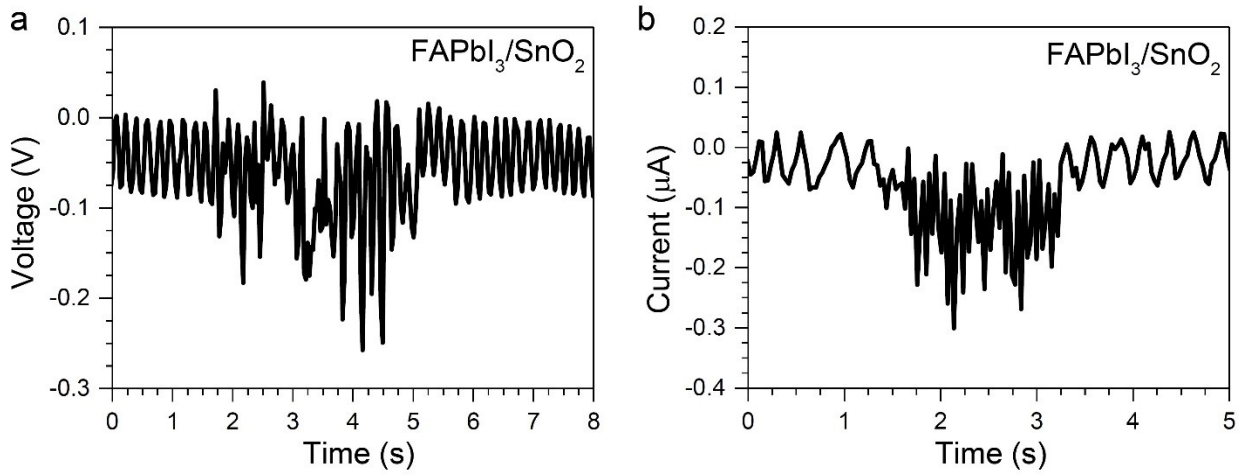

Figure S17. (a) Voltage and (b) current performance of the dynamic $FAPbI_3/SnO_2$ heterojunction by pressing and sliding the SnO_2-coated electrode on the $FAPbI_3$-coated electrode. The applied force was ~5 N and the contact area was ~1 cm^2.

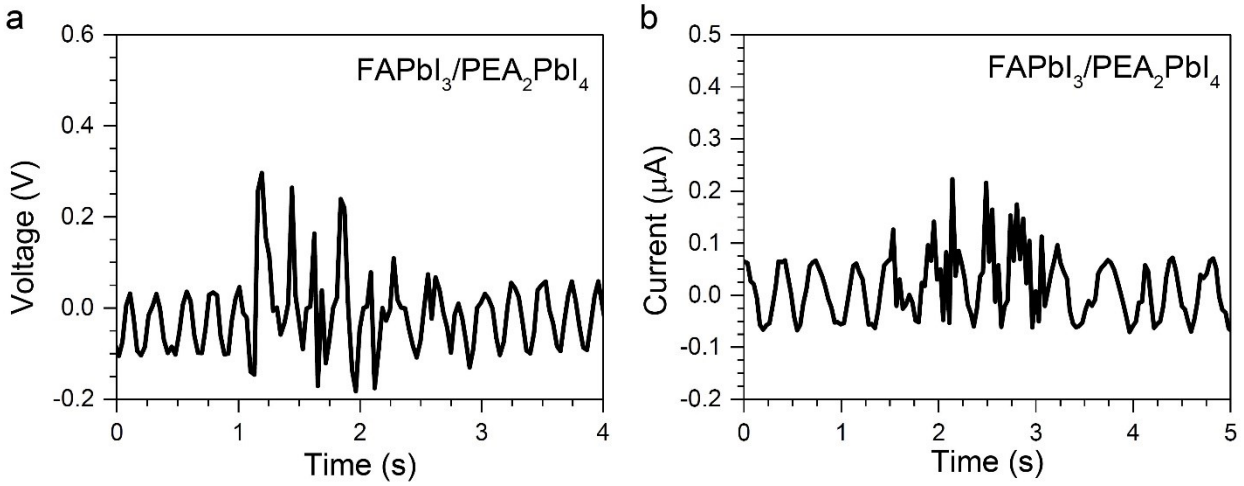

Figure S18. (a) Voltage and (b) current performance of the dynamic $FAPbI_3/PEA_2PbI_4$ heterojunction by pressing and sliding the PEA_2PbI_4-coated electrode on the $FAPbI_3$-coated electrode. The applied force is ~5 N and the contact area is ~1 cm^2.

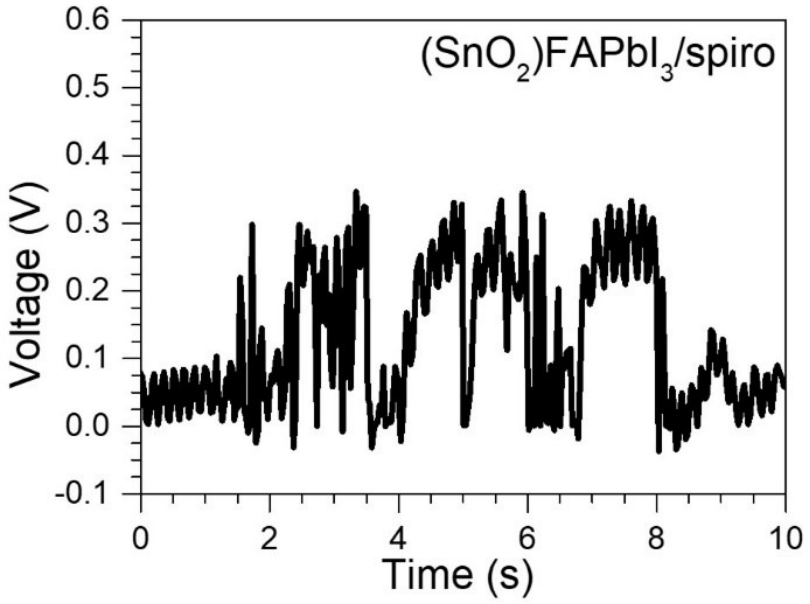

Figure S19. Voltage performance of the dynamic $FAPbI_3$/spiro heterojunction with SnO_2 as ETL under the perovskite film. The applied force is ~5 N and the contact area is ~1 cm^2.

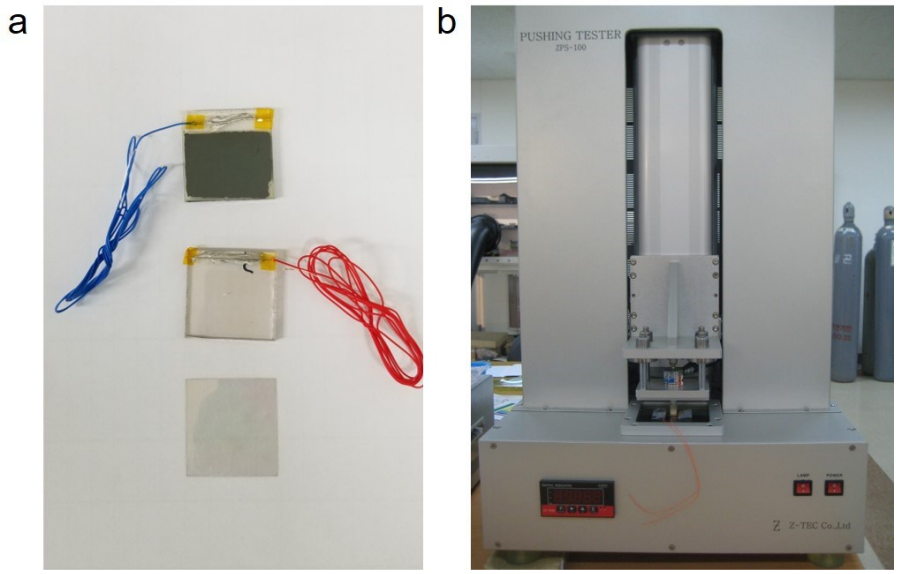

Figure S20. Digital photos of (a) the samples and (a) the setup for applying forces. Samples from up to down in (a) are FTO glass/perovskite, FTO glass/spiro, and PEN/ITO/spiro, respectively.