Electronic Supplementary Material (ESI) for RSC Advances.

Supplementary Materials

UV ozone treatment for oxidization of Spiro-OMeTAD hole transport layer

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Contents

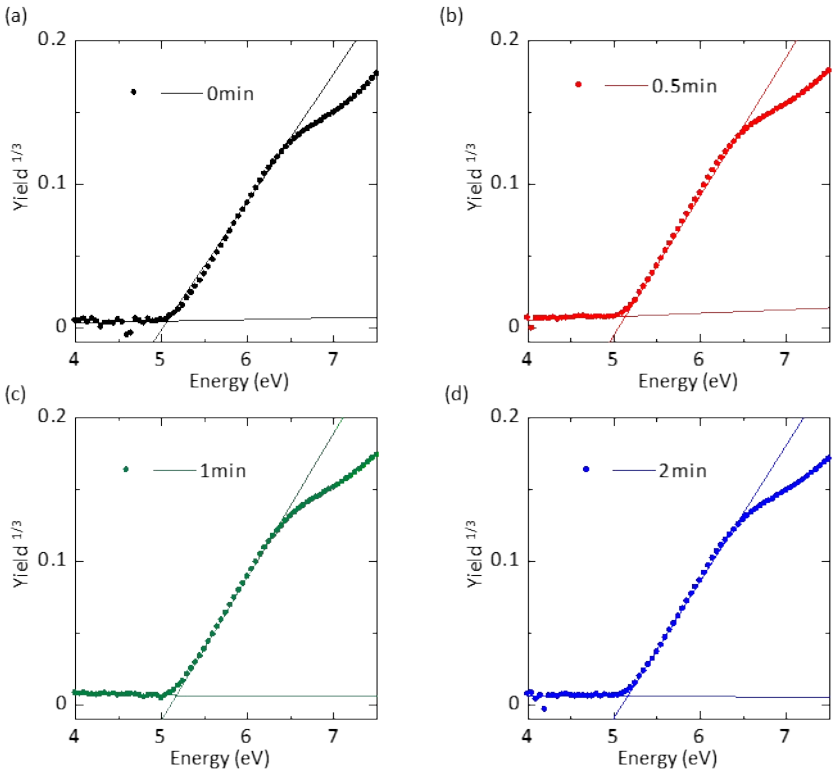

Figure S1 Photoelectron yield spectroscopy results for spiro-OMeTAD with UV ozone exposure for (a) 0 seconds, (b) 30 seconds, (c) 1 minute, and (d) 2 minutes. The HOMO energy is estimated from the crossing point of two extrapolated lines of experimental data. As shown in Fig. 3 in the main manuscript, the HOMO energy shows a decreased trend with UV ozone treatment time.

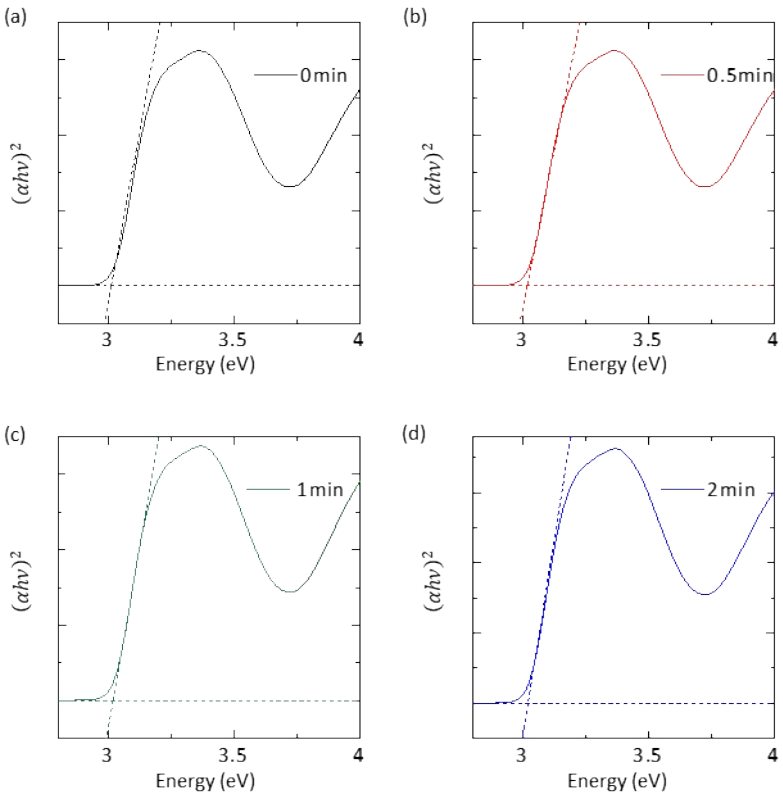

Figure S2 Tauc plot analyses for the absorption spectra of spiro-OMeTAD with UV ozone exposure for (a) 0 seconds, (b) 30 seconds, (c) 1 minute, and (d) 2 minutes. We assume a direct arrowed transition. The estimated band gap energy does not significant variation against UV ozone treatment time.

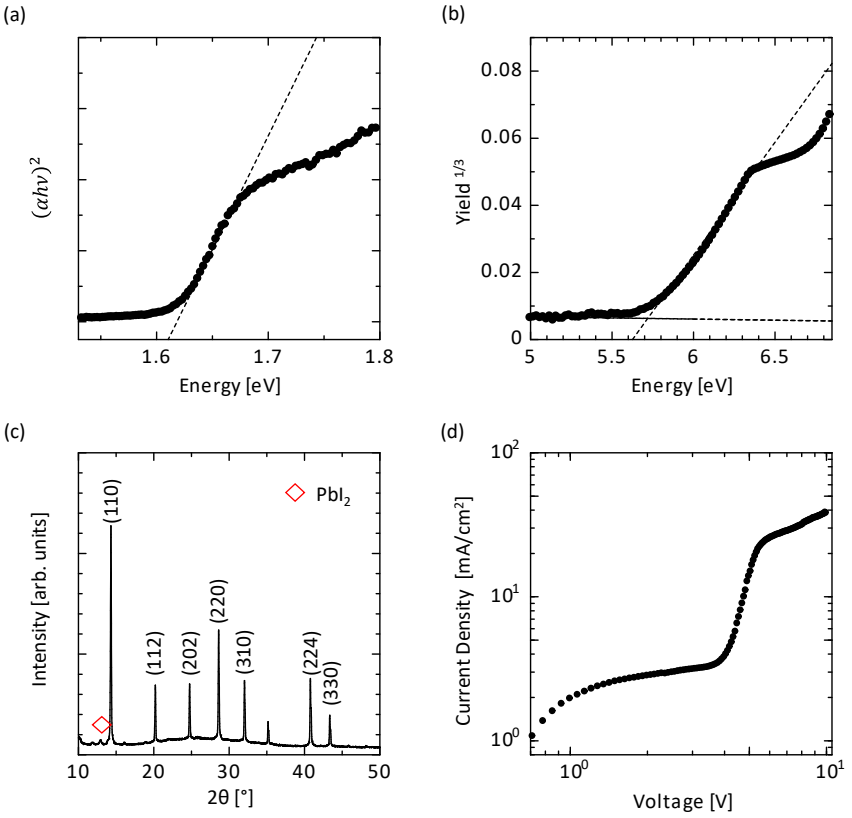

Figure S3 Fundamental properties of perovskite film fabricated in this study. (a) Tauc plot analyses of absorption spectra. The band gap energy is estimated as ~1.62 eV. (b) Photoelectron yield spectra. The valence band maximum energy is evaluated to be ~ -5.73 eV. (c) X-ray diffraction pattern. A polycrystalline film with a cubic crystal structure is confirmed. (d) Current density-voltage profile of a hole-only device with a ITO/PEDOT:PSS/perovskite/spiro-OMeTAD/Au structure, exhibiting ohmic, trap-filling, and SCLC regimes at low-, middle, and high-voltage regions, respectively.

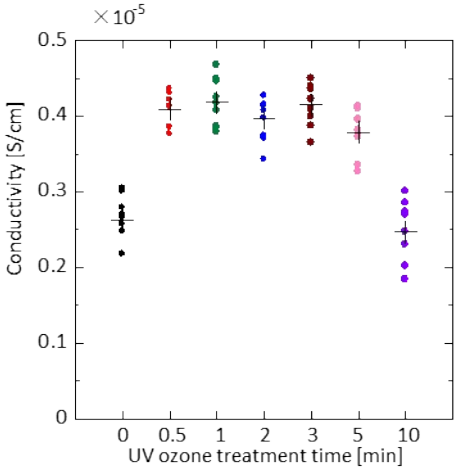

Figure S4 Conductivity of spiro-OMeTAD films as a function of with UV ozone treatment time (30 s~10 minutes). Closed circles and crosses show experimental results and their mean values, respectively. It is found that the long UV ozone exposure time results in degradation of conductivity.

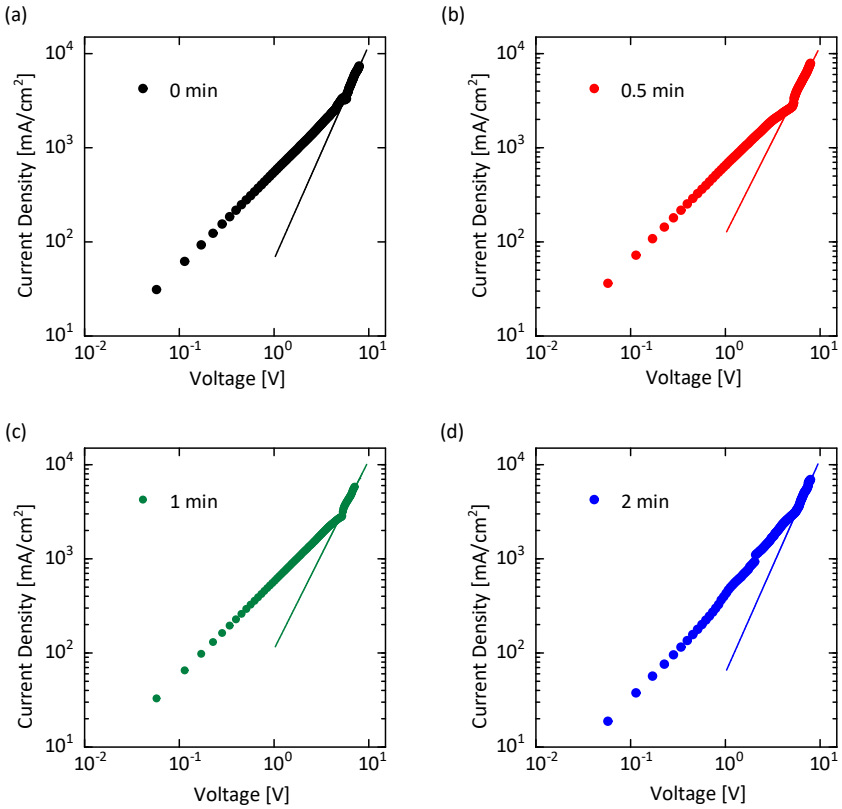

Figure S5 *J-V* characteristics showing space-charge-limited current (SCLC) regime of spiro-OMeTAD films with UV ozone exposure for (a) 0 seconds, (b) 30 seconds, (c)1 minute, and (d) 2 minutes. The SCLC regime is observed above ~5 V. The mobility is evaluated from a quadratic function exhibited by a solid line.

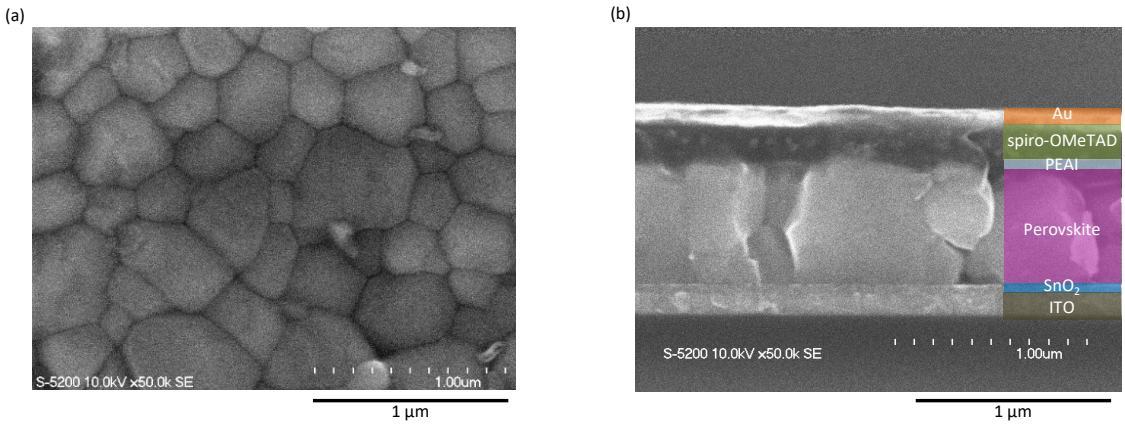

Figure S6 Scanning electron microscopic (SEM) observations of perovskite solar cell device. (a) Surface SEM image of perovskite layer deposited on a SnO_2/ITO structure. The film consists of perovskite polycrystal with grain sizes of 200 – 500 nm. (b) Cross-sectional SEM image of the solar cell device. PEAI, oxidized spiro-OMeTAD, and Au layers are deposited onto this surface. The thicknesses of perovskite and spiro-OMeTAD are ~600 and ~250 nm, respectively.

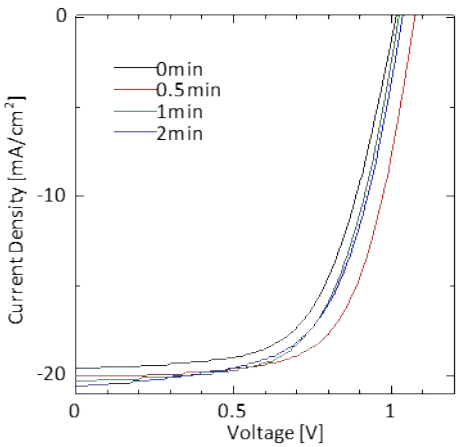

Fig. S7. Current density-voltage curves under the AM 1.5G illumination of the best solar cell samples. The best device performance is obtained at 0.5 min of UV ozone treatment time for spiro-OMeTAD hole transport layer.

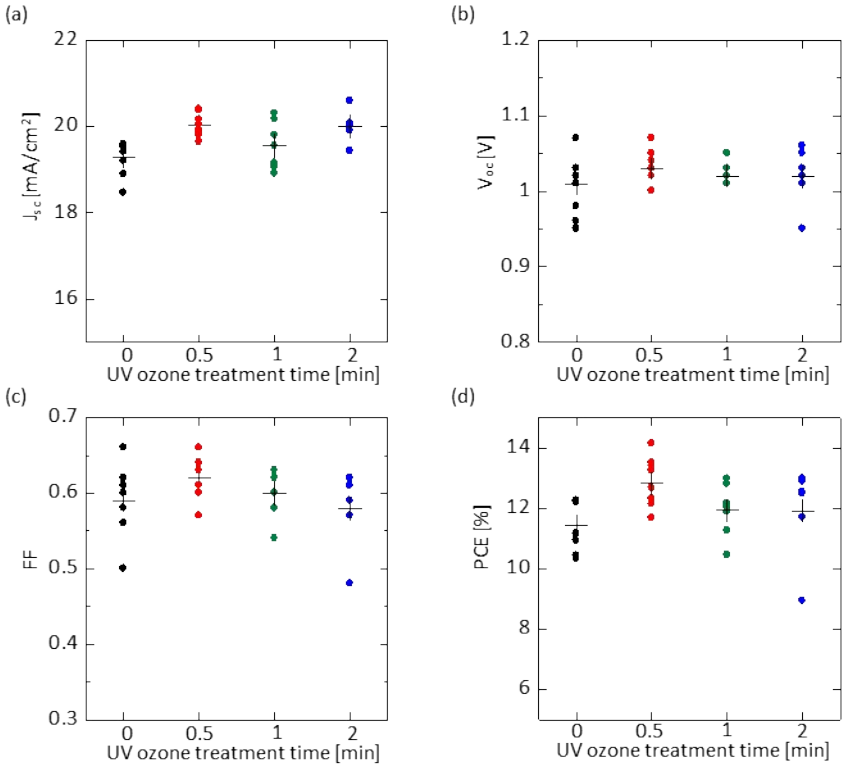

Figure S8 Photovoltaic parameters of solar cell devices with UV ozone treated spiro-OMeTAD hole transport layer. (a) Short-circuit current density, (b) open-circuit voltage, (c) filling factor, and (d) power conversion efficiency. Closed circles and crosses show experimental results and their mean values, respectively.