

Electronic Supplementary Information

Aluminum nanoparticles for high efficient and stable organic photovoltaics

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Experimental Procedures

Synthesis of Al NPs: The generation of the Al nanoparticles was performed by femtosecond (~100fs@1kHz) laser ablation of Al metallic target (99.99%) placed into a Pyrex cell and covered by a layer of absolute ethanol. This technique generates a large variety of NPs that are free of both surface-active substances and counter-ions. Additionally, the advanced pulsed laser ablation method used is capable of highly uniform target irradiation, and consequently generation of NPs over a controlled size range with a high degree of reproducibility. More details can be found elsewhere¹.

Device fabrication: Regioregular P3HT (Rieke Metals) and PCBM (NANO-C) based OPV devices were dissolved in dichlorobenzene (*o*-DCB) in a 1:1 ratio and stirred overnight at 75 °C. The photovoltaic devices reported were fabricated on 15 mm by 15 mm indium–tin-oxide (ITO) glass substrates with a sheet resistance of 8–12 Ω/sq. As a buffer layer, poly(ethylenedioxythiophene) doped with poly(4-styrenesulfonate) (PEDOT:PSS), was spin-cast from an

aqueous solution on the ITO substrate at 5000 rpm for 30 seconds and the average thickness of the layer was 40 nm, followed by baking for 15 min. at 120 °C inside a nitrogen-filled glove box. Then the metallic NPs were blended into the P3HT:PCBM solution at different weight ratios (wt%). Composite blends with 8, 9 and 10 wt% Al NPs were prepared. All hybrid photoactive layers were subsequently deposited by spin-coating the blend solutions at 1000 rpm on top of PEDOT:PSS layer. Aluminum metal cathodes were deposited by a thermal evaporator through a shadow mask. The devices were post-annealed at 160 °C for 15 min in a glove box under nitrogen atmosphere. In all cases, the final active layer thickness, determined from cross-sectional SEM images is measured to be approximately 220nm. The active device area was measured with a microscope, showing a value of ~18 mm².

The performances of the devices were measured at room temperature with an Air Mass 1.5 Global (A.M. 1.5 G) solar simulator at an intensity of 100mW/cm². A reference monocrystalline silicon solar cell from Newport was used to calibrate the lamp. The device exhibiting the best initial PCE was that incorporating 9 wt% Al NPs. IPCE curves were recorded for the reference and devices with the optimum blend ratio by monitoring the short circuit current of the PV devices with a lock-in amplifier using the chopped, monochromatic light from a Xe lamp as an illumination source. All measurements were carried out in air immediately after device fabrication. Detailed information of the optimized fabrication and characterization conditions for the pristine ITO/PEDOT:PSS/P3HT:PCBM/Al can be found elsewhere².

References

1. E. Stratakis, M. Barberoglou, C. Fotakis, G. Viau, C. Garcia, G.A. Shafeev, *Opt. Express*, 2009, **17**, 12650
2. E. Kymakis, G.D. Spyropoulos, M.M. Stylianakis, E. Stratakis, E. Koudoumas, C. Fotakis, *Solar Energy Materials and Solar Cells*, 2012 **96**, 298

Figures

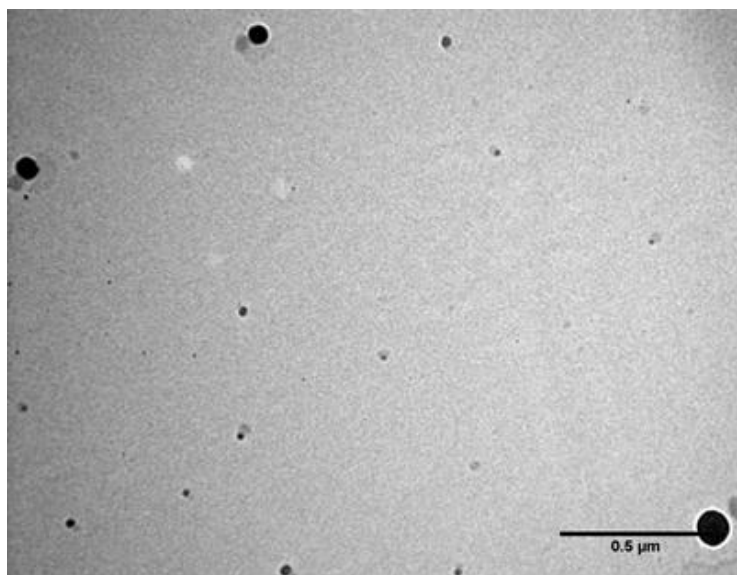


Figure S1. TEM image of the fabricated Al NPs.

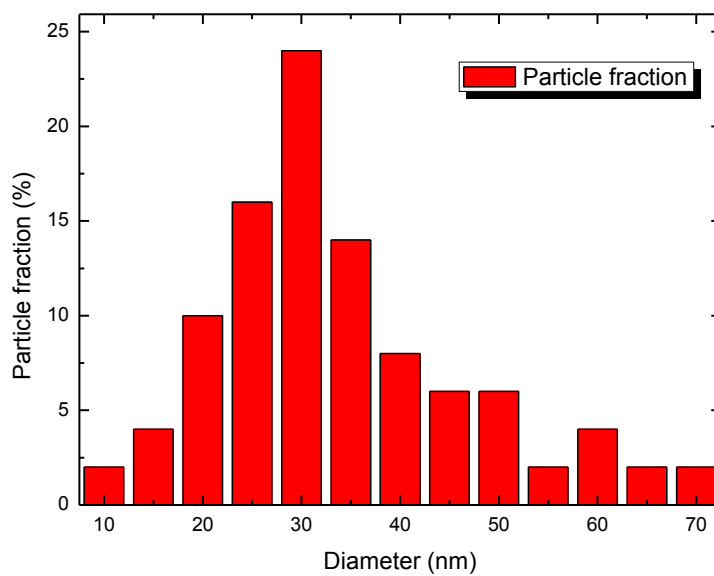


Figure S2 Size distribution of the fabricated nanoparticles.

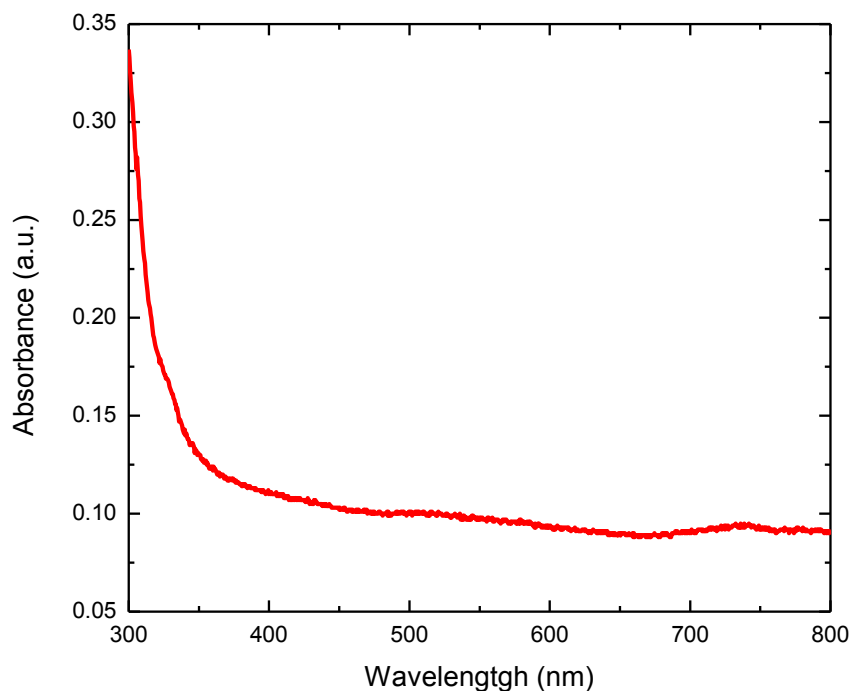


Figure S3. Absorption spectrum of the Al NPs in ethanol with the peak at ~300 nm.

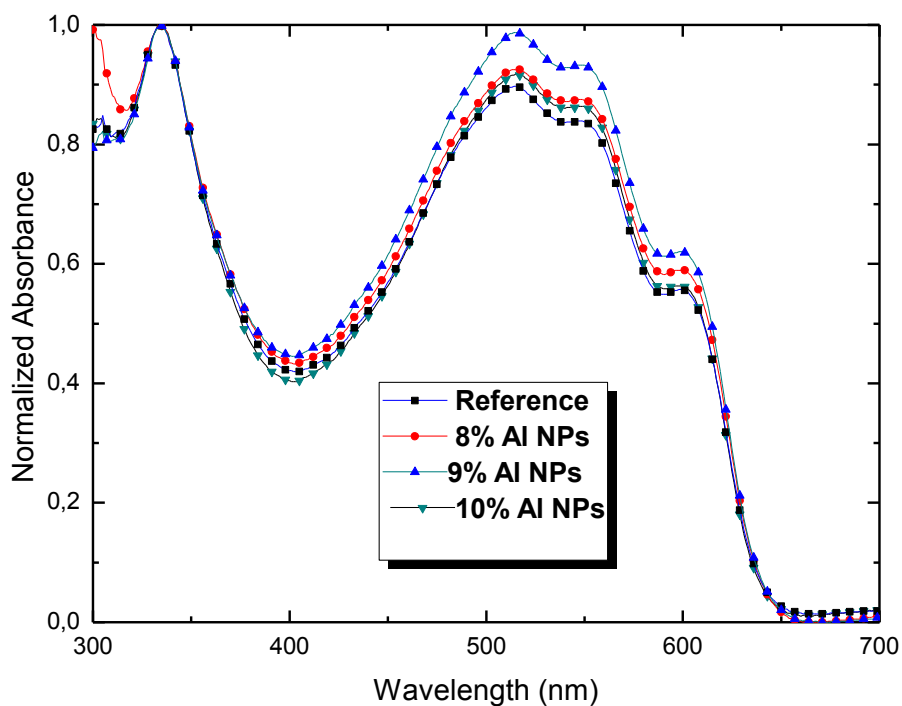


Figure S4 Normalized absorption spectra of the BHJ devices with Al NPs incorporated in the photoactive layer in different concentrations (the absorbance is baseline corrected with the PEDOT:PSS/ITO/glass substrate as a reference).