Large scale, Flexible and Three-dimensional Quasi-ordered Aluminum Nanospikes for Thin Film Photovoltaics with Omnidirectional Light Trapping and Optimized Electrical Design

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Supplementary Information

Morphology characterization, optical reflectance and device performance characterization of solar cell

Morphologies of the NSP and thin film were examined by SEM using a JEOL6700F at an accelerating voltage of 5kV. The *I-V* characteristics of all the solar cell were characterized by Oriel solar simulator, 450 W Xe lamp, AM 1.5 global illumination with output calibrated to 1 sun (100 mW cm^{-2}) with mono-crystalline reference cell (Newport corporation, 91150V) and Keithley 2400 source meter. EQE measurement was carried out by Oriel QE-PV-SI, Newport Corporation. Diffused reflectance spectra were carried out on the solar cell surface using a Perkin-Elmer UV/vis spectrophotometer (model Lambda 20).

Daily integrated power output ratio

The daily power output shown in Fig. 4c assumes that the solar cell and the sun are confined within the equatorial plane with the device facing the sun at noon. Efficiencies of solar cell from $-60^{o} \sim 0^{o} \sim 60^{o}$ with 10^{o} interval were measured under AM 1.5G condition. It is assumed that sunlight incident angle changed by 10^{o} every 40 minutes. Therefore $-60^{o} \sim 0^{o} \sim 60^{o}$ is corresponding to 8 a.m. to 4 p.m. and daily integrated power output ratio over planar is defined as the ratio between integrated efficiency of NSP solar cell from $-60^{o} \sim 0^{o} \sim 60^{o}$ and integrated efficiency of planar solar cell from $-60^{o} \sim 0^{o} \sim 60^{o}$.

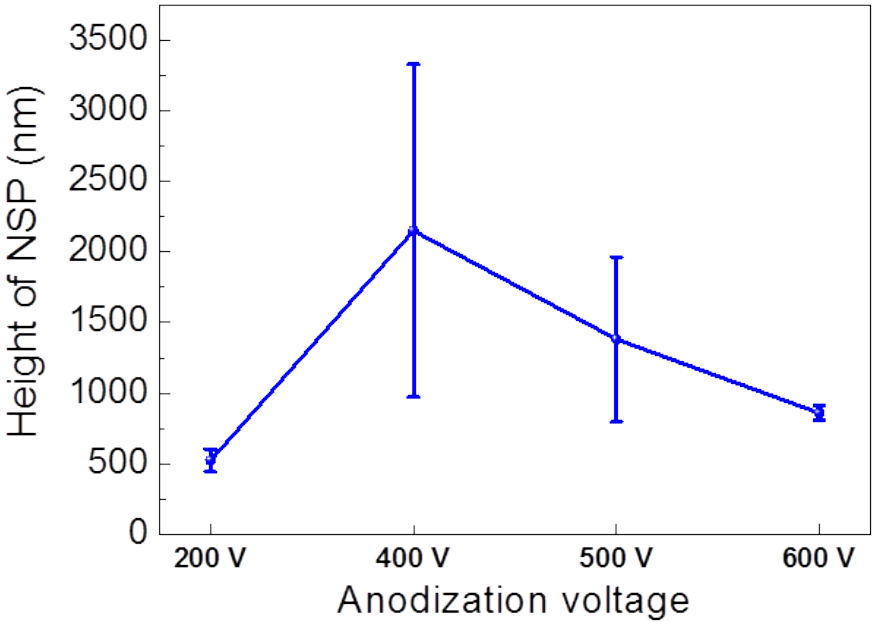

Figure S1. Statistical data of NSP height by different anodization voltages

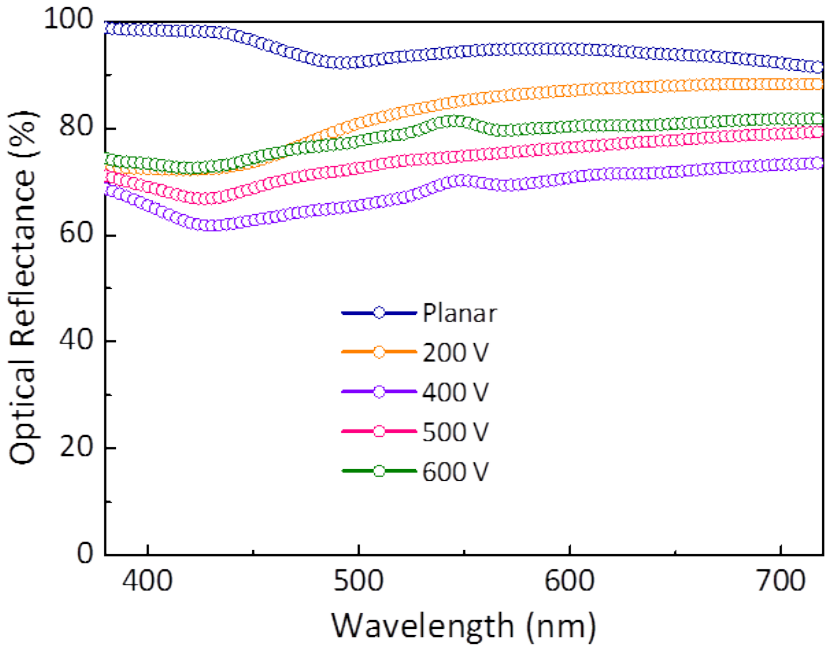

Figure S2. Normal incidence optical reflectance of NSP by different anodization voltages

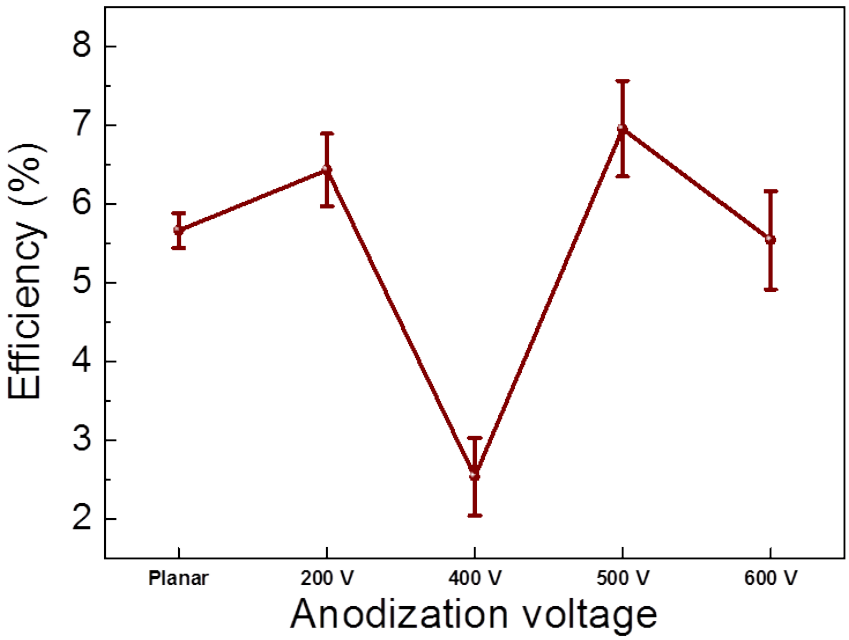

Figure S3. Statistical data of PV device efficiencies based on NSP by different anodization voltages

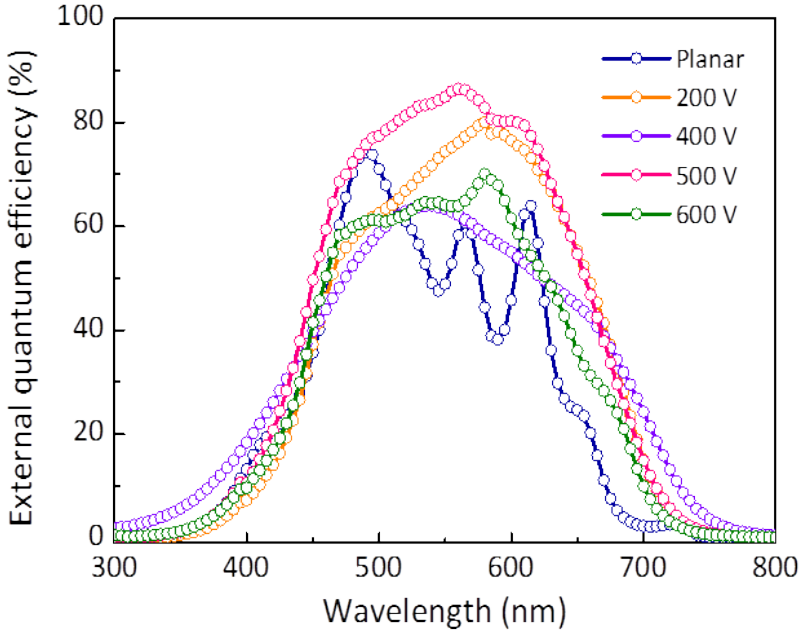

Figure S4. External quantum efficiency (EQE) of a-Si:H solar cells on different morphologies NSP

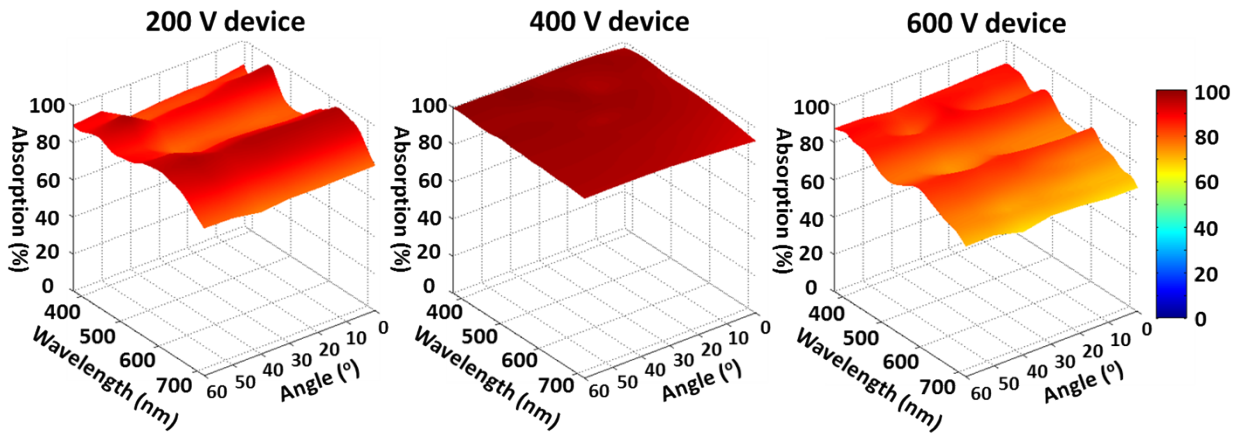

Figure S5. Angular and wavelength dependent absorption spectra of solar cell on 200 V, 400 V and 600 V NSP substrate