Electronic Supplementary Material (ESI) for Nanoscale.

# Supporting Information: Light Trapping in Thin Film Silicon Solar Cells via Phase Separated Disordered Nanopillars

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## 1 Tuning the morphology of the nanopillars array

Tuning the in-plane morphology of the NP array is achieved by adjusting the polymer blend composition and the spin-coating parameters. Fig. S1(a) shows schematically the relationship between the blend composition and the size of the PS domains within the PMMA matrix. By increasing the mass ratio of PS in the blend composition (PS:PMMA mass ratio varied from 2:8 to 4:6), the mean diameter of the PS NP increases as evidenced by the SEM images of the fabricated samples (Figs. S1(b)-(c)). It was suggested in Ref.[1] that two or more neighboring domains could merge, resulting in the formation of larger (PS) islands. Moreover, Fig. S1(d) illustrates the effect of increasing the spin-coating speed by setting the PS:PMMA mass ratio to 4:6 (compare with Fig. S1(c)). By increasing the spin speed (from 800 rpm to 3000 rpm), the density of the PS NP increases. The influence of the rotation speed can be explained by the change in the evaporation rate of the solvent. Because the evaporation of the mutual solvent (MEK) is accelerated by increasing the spin speed, the mobility of both polymers decreases. These kinetically driven behaviors compelled to adjust the mixing structure from an unstable state to a stable one and they might be frozen at their metastable states.[1]

Aside the in-plane morphology of the NP, their mean height can also be tuned, for example by adapting the spin speed[2] (whereby a higher speed leads to thinner blend films) or by changing the solution concentration.[3] However, these approaches simultaneously affect the in-plane morphology of the NP array. To circumvent this issue and only act on the NP height, we treat the phase-separated PS/PMMA blends by $O_2$ plasma after spin-coating, as illustrated in Fig. S2 (a). The plasma treatment is carried out before the selective development of PMMA to maintain the diameters of the NP. The SEM images reported in Fig. S2 (b)-(e) demonstrate this point. After 2 min of $O_2$ plasma, the NP mean height is reduced by more than half while the lateral dimensions of the NP are preserved. We nevertheless note that for an exposure of 3 min (Fig. S2 (e)), the diameter of the NP is significantly reduced due to the complete stripping of the PMMA after 2 min of $O_2$ plasma treatment.

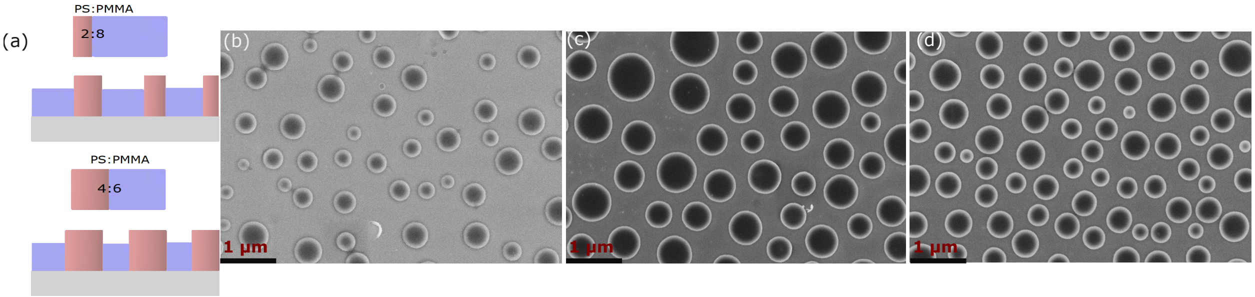

**Figure S1:** Tuning of the in-plane morphology of the NP array. (a) Schematic illustrating the evolution of the morphology of the phase-separated films following an increase of the PS weight ratio in the blend composition. The SEM pictures show an increase of the NP diameters when the PS:PMMA weight ratio is changed from 2:8 (b) to 4:6 (c). By increasing the spin speed from 800 rpm (c) to 3000 rpm (d), the density of the NP can be increased, which comes along with a reduction of the NP diameters.

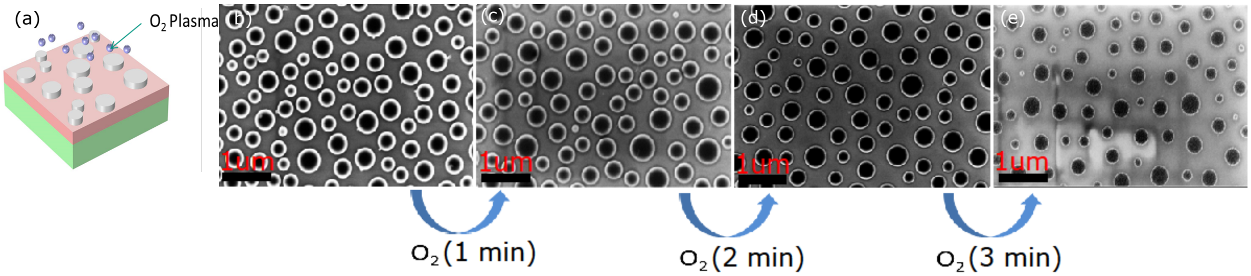

**Figure S2:** Tuning of the NP mean height. (a) Schematic of the oxygen plasma treatment applied to the phase-separated films prior to PMMA development. The SEM images of the samples before (b) and after (c-e) exposure to the oxygen plasma are also reported. The corresponding NP mean height, measured by AFM, are: (b) 150 nm, (c) 100 nm, (d) 70 nm, and (e) 20 nm.

## 2 Front side texture of the fabricated a-Si:H solar cells

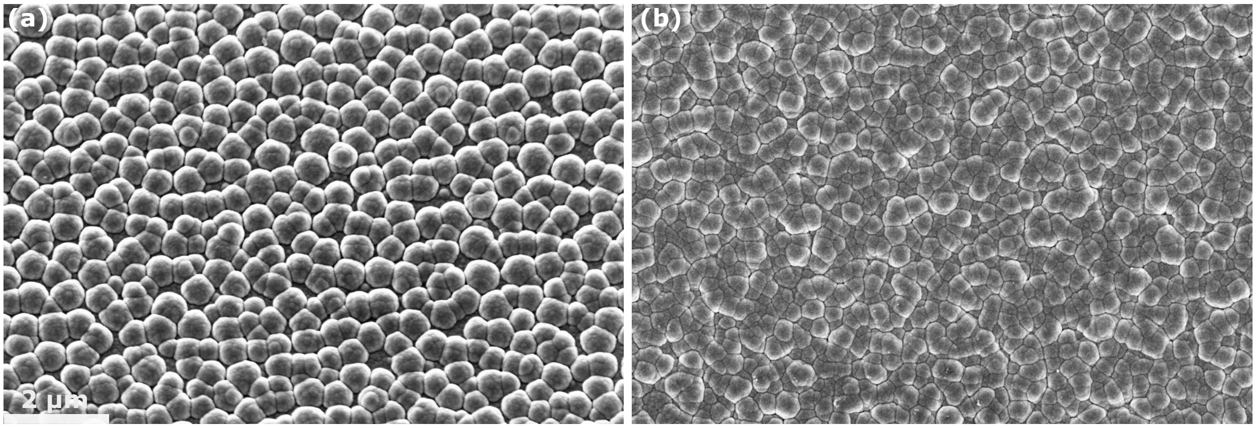

**Figure S3:** SEM top-view images of the front side (ZnO:Al layer) of the solar cells based on (a) NP, and (b) Asahi texture.

## 3 Influence of the NP height on the front side texture of the solar cells

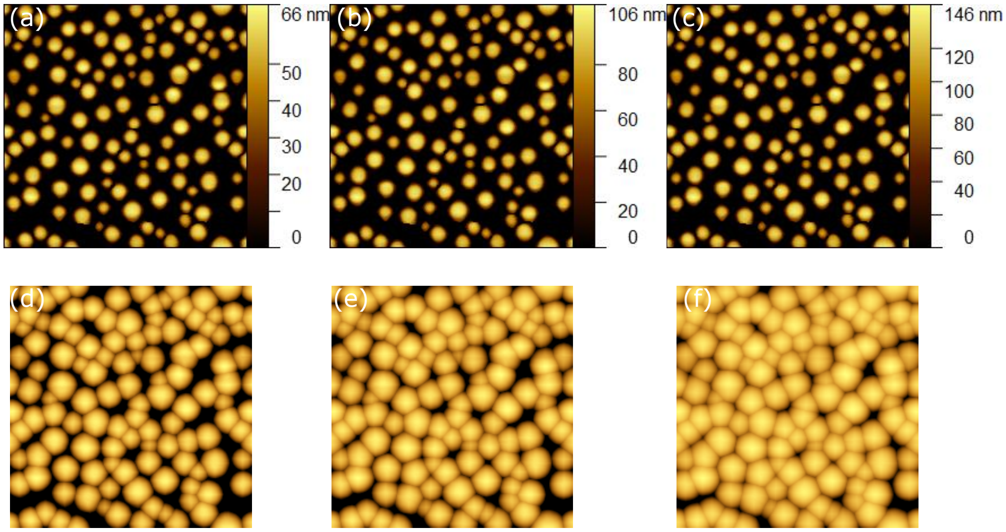

**Figure S4:** (a)-(c) Texture of the PS NP derived from AFM measurements. The profiles shown in (a) and (c) are generated by down- or up-scaling the measured profile displayed in (b). The corresponding front side textures (ZnO:Al layer exposed) are subsequently modeled and shown in (d)-(f).

# 4 Influence of the NP surface coverage on the front side texture of the solar cells

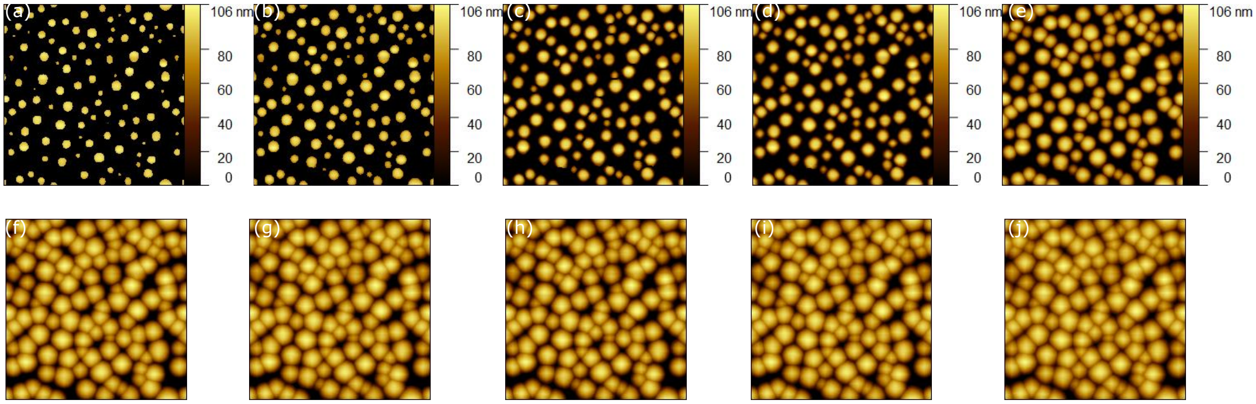

**Figure S5:** (a)-(e) Texture of the PS NP derived from AFM measurements. The profiles shown in (a),(b),(d) and (e) are generated by increasing or decreasing the lateral size of the PS domain measured by AFM and shown in (c). Thus, base surface has a surface coverage of (a) 13% (b) 24% (c) 30% (d) 34% (e) 49%. The corresponding front side textures (ZnO:Al layer exposed) are subsequently modeled and shown in (f)-(j).

# 5 Influence of the NP surface coverage on the light harvesting properties of the a-Si:H solar cells

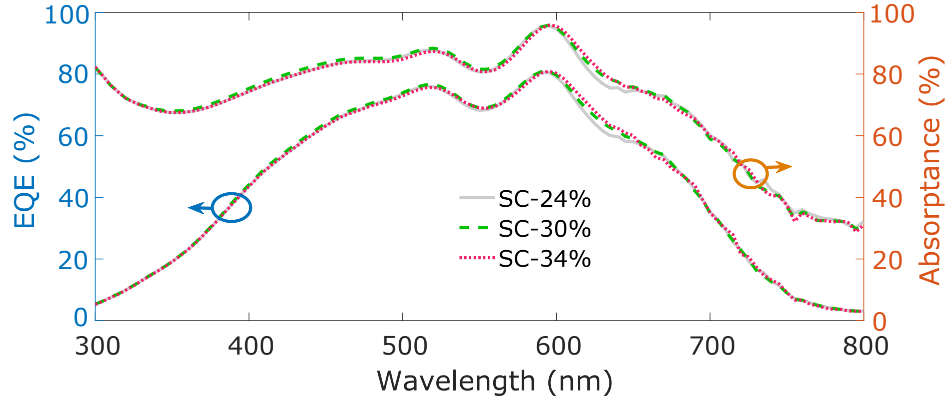

**Figure S6:** The EQE and absorption spectra are simulated for NP surface surface coverage ($SC$) varying from 24% to 34%. A weak influence of $SC$ on the light harvesting properties of the cells is observed.

# References

(1) Huang, C. Phase Separation in Thin Polymer Films: From Self Stratification to Polymer Blend Lithography. Ph.D. thesis, Technische Universität, 2015.

(2) Walheim, S.; Böltau, M.; Mlynek, J.; Krausch, G.; Steiner, U. *Macromolecules* **1997**, *30*, 4995–5003.

(3) Fang, L.; Wei, M.; Barry, C.; Mead, J. *Macromolecules* **2010**, *43*, 9747–9753.