Supplementary Materials for

Bioinspired phase-separated disordered nanostructures for thin photovoltaic absorbers

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Published 20 October 2017, Sci. Adv. 3, e1700232 (2017)
DOI: 10.1126/sciadv.1700232

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**Supplementary Materials**

**fig. S1.** Matt black and dull black scales of the *P. aristolochiae* butterfly wings. SEM images of scales from the matt- (A) and dull- (B) black region reveal the hole density (air $ff$) difference between the two regions. (C) Absorption spectra measured from the apex of scales of both regions.
**fig. S2.** Optical indices of the materials considered for the simulations. (A) Real (n) and imaginary (k) part of the considered refractive index of chitin-melanin composite of *Pachliopta aristolochiae* wing tissues. (B) Real (n) and imaginary (k) part of the refractive index of a-Si:H taken from Ref. (45).

**fig. S3.** Simulated absorption spectra of different perturbed patterned PV absorbers. Simulated polarization-averaged absorption spectra (A) and integrated absorption values (B) of different perturbed geometries of 100 nm thick a-Si:H absorbers using a Gaussian distribution of hole diameter distribution with a mean of 240 nm and a variance of 20 nm.
fig. S4. Polarization and angle-resolved simulated absorption spectra of the different patterned thin PV absorbers considered in Fig. 3.
fig. S5. Air-filling fraction influence on absorption properties of PV absorber patterned with correlated disorder design. The air filling fraction of the “correlated” patterned thin PV absorber depicted in Fig. 3A is varied from 0% to 60% with a step of 10%. The simulated absorption spectra are provided with corresponding integrated absorption (IA) values.
fig. S6. Comparison of simulated absorption spectra of unpatterned, ordered, and bioinspired nanohole patterned solar cells. Schematic view of the simulated patterned solar cells integrating the ‘correlated’ nanoholes design. Bio-inspired nanoholes are drilled into the ITO (50 nm) and active a-Si:H (130 nm) layers, which are located on top of an optical spacer (ZnO – 100 nm) and a metallic back reflector (Ag – 50 nm). The ff of the patterned configuration is set to 50.26%. For comparison, an equivalent but unpatterned and ‘ordered’ nanohole patterned solar cell is also simulated. The absorption spectra of the three solar cells simulated under normal angle of incidences (AOI) for unpolarized light ((TE+TM)/2) are provided along with the absorption spectra of the sole active layer. The corresponding integrated absorption (IA) values are reported in brackets.

fig. S7. Simulated absorption spectrum of a 100-nm-thick a-Si:H film patterned with exact high absorbing nanohole geometry of P. aristolochiae butterfly wings.
fig. S8. Simulated absorption spectra of the *P. aristolochiae* butterfly wings obtained with a nanohole array made of the “actual” and correlated arrangement. The former corresponds to the one used in Fig. 2, and the latter was designed in a ‘correlated’ manner with the statistical nanohole distribution of matt-black butterfly scales. For comparison, the experimental spectrum stemming from Fig. 2 is also reported.