Radiative cooling of solar cells: supplementary material

LINXIAO ZHU¹, AASWATH RAMAN², KEN XINGZE WANG³, MARC ABOU ANOMA⁴,
AND SHANHUI FAN⁵

¹Department of Applied Physics, Stanford University, Stanford, California 94305, USA

²Department of Electrical Engineering, Ginzton Laboratory, Stanford University, Stanford, California 94305, USA

³Department of Applied Physics, Stanford University, Stanford, California 94305, USA

⁴Department of Mechanical Engineering, Stanford University, Stanford, California 94305, USA

⁵shanhui@stanford.edu

⁵Department of Electrical Engineering, Ginzton Laboratory, Stanford University, Stanford, California 94305, USA

Published 22 July 2014

We show that the silica pyramid design is compatible with anti-reflection coating on solar cells. This document provides supplementary information to "Radiative cooling of solar cells", <http://dx.doi.org/10.1364/optica.1.000032> © 2014 Optical Society of America

<http://dx.doi.org/10.1364/optica.1.000032.s001>

We show that the silica pyramid design is compatible with anti-reflection coating on solar cells. Adding the silica pyramid on a solar cell with anti-reflection coating does not degrade the solar absorptivity of the cell. As a typical example of an anti-reflection coating used in solar cell, a 75 nm-thick Si_3N_4 uniform layer is placed on top of the silicon structure (Fig. S1a). The dielectric constant of silicon nitride for optical simulation is obtained from Ref. [1]. As thermal emitter structures we then place either a 5 mm-thick silica layer (Fig. S1b), or the silica pyramid (Fig. S1c), on top of the silicon cell with Si_3N_4 layer. In Fig. S1d, we compare the solar absorptivities of the three structures shown in Fig. S1a-c. For the 75 nm Si_3N_4 on silicon structure (Fig. S1d, blue curve), absorptivity is close to unity at around 600 nm, which corresponds roughly to the peak of AM1.5 solar spectrum. For the 5 mm silica structure (Fig. S1d, green curve) and the silica pyramid structure (Fig. S1d, red curve), the absorptivity generally maintains, compared with the bare silicon with silicon nitride structure. The photocurrents for the bare silicon with silicon nitride structure, the 5 mm silica structure, and the silica pyramid structure, are 36.8 mA/cm², 36.5 mA/cm² and 37.8 mA/cm², respectively. Therefore, the silica pyramid structure does not degrade the solar absorptivity of the solar cell, (in fact, the use of pyramid slightly improves the photocurrent), and is compatible with anti-reflection coating.

REFERENCES

1. E. Palik, Handbook of Optical Constants of Solids, Vols. I, II, and III (Elsevier Science & Tech: New York, 1985).

Fig. S1. (a)-(c) Three-dimensional crystalline silicon solar cell structures. (a) Bare solar cell with 200 μm-thick uniform silicon layer under a 75 nm-thick Si_3N_4 anti-reflection layer, on top of an aluminum back reflector. (b) A 5mm-thick uniform silica layer atop structure in (a). (c) A two-dimensional square lattice of silica pyramids and a 100 μm-thick uniform silica layer, atop structure in (a). (d) The emissivity and absorptivity spectra of solar cells structures in (a)-(c), for normal direction and after averaging over polarizations.