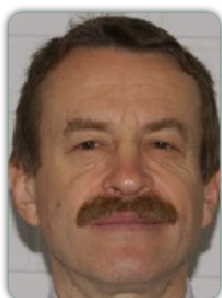


24th World Nano Conference

May 07-08, 2018 | Rome, Italy



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Affordable large-area nanotechnologies for enhancement of thin-film solar cells

Statement of the Problem: Photon management with nanostructures represents one of the most promising ways to further advances in performance of thin-film solar cells (TFSCs). During the last decade the idea of light-trapping in TFSCs was compromised by an amount of work which have not resulted in something practical. We are especially keen for amorphous-silicon TFSCs for which light-trapping structures (LTSs) should play the key role, because the optimal thickness of the active p-i-n structure (300-400 nm) is insufficient for the light absorption per one passage and the flexible implementation of the bottom electrode implied optical losses in it instead of a back reflector. Researchers suggested hundreds of LTSs for such TFSCs, mostly based on plasmonic nanostructures. None of them were industrially adapted: either they are inefficient themselves, or worsen the photovoltaic operation, or, finally, their cost exceeds that of the TFSC, in contradiction with the insight of thin-film solar photovoltaics as cheap solar electricity.

Methodology & Theoretical Orientation: In our group we have found that the optimal photovoltaic layer in a-Si TFSCs (intrinsic a-Si) is sufficient for trapping the light via the so-called photonic nanojets (PNJ), formed by a void cavity or nanolens illuminated by a plane wave. The PNJ regime is broadband and its use in the novel LTSs is our governing idea. We have suggested and theoretically studied several types of LTSs suitable for a-Si TFSCs, based on regular lens and cavity arrays. We also found the needed regime in the arrays of microcones.

Findings: We found affordable technologies for producing such arrays: self-assembly on silica spheres from colloids, atomic layer deposition of transparent conductive oxide, ion-beam etching, optical interference lithography. Our experiments confirmed our theory.

Conclusions & Significance: Our work may result in a technical breakthrough, revitalizing the industry of amorphous silicon solar cells on flexible substrates.

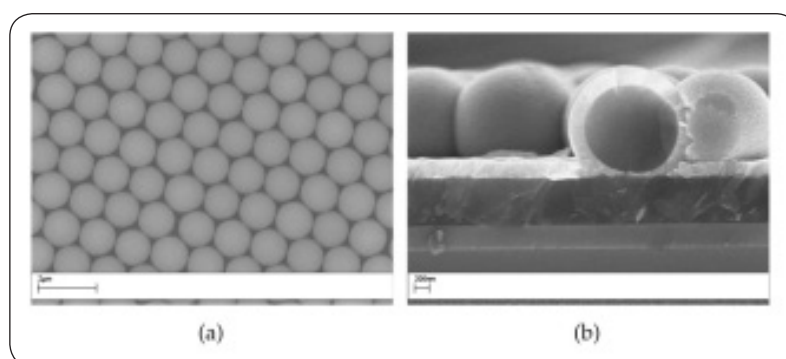


Figure 1: SEM image of one of our LTSs on two stages of fabrication: (a) – top view of a sample covered by self-assembled colloidal nanoparticles, (b) – side cross section after the deposition of one half of the 600-nm thick layer of the transparent electrode (Al-doped Zinc Oxide)

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Recent Publications

1. Voroshilov P M and Simovski C R (2017) Affordable universal light-trapping structure for third-generation photovoltaic cells. *JOSA B* 34(7):D77.
2. Omelyanovich M and Simovski C (2017) Wide-angle light-trapping electrode for photovoltaic cells. *Opt. Lett.* 42(19):3726-3729.
3. Mirmoosa M S, Biehs S A and Simovski C R (2017) Super-Planckian thermophotovoltaics without vacuum gaps. *Phys. Rev. Appl.* 8:054020.
4. Valagiannopoulos C, Simovski C and Tretyakov S (2017) Breaking the black-body limit with resonant surfaces. *EPJ Applied Metamaterials*. 4:1-6.
5. Milichko V A et al. (2016) Solar photo-voltaics: current state and trends. *Physics Uspekhi* 59(8):727-772.

Biography

Constantin R Simovski defended his PhD thesis in 1986 in the Leningrad Polytechnical Institute, now called St.-Petersburg Polytechnical University (Russia). In 2000, he defended in the same university the thesis of Doctor of Sciences in Physics and Mathematics. He has worked in both industry and academy in several countries. He got a post of a Full Professor in the ITMO University, St. Petersburg, Russia in 2001. Since 2008 he has been with Helsinki University of Technology, now – Aalto University (in 2008-2012 as a Tenure Professor, since 2012 as a tenure-track Full Professor). His current research includes: new metamaterials for optical sensing and energy harvesting, advanced solar cells, radiative heat transfer and thermophotovoltaics, homogenization and electromagnetic characterization of metamaterials/metasurfaces.

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