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Silicon Quantum Dot Intermediate Band Solar Cell

Weiguo Hu[1, 2], Makoto Igarashi[1, 2], Mohd Erman Fauzi[1, 2], Akio Higo[4], Ming-Yi Lee[3], Yiming Li[3,4], and Seiji Samukawa[1, 2, 4 *]

[1] Institute of Fluid Science, Tohoku University

[2] Japan Science and Technology Agency, CREST

[3] Department of Electrical Engineering, National Chiao Tung University

[4] WPI Advanced Institute for Materials Research, Tohoku University

E-mail:samukawa@ifs.tohoku.ac.jp

Si-based solar cell has the widest commercial applications due to large element abundant and mature device process. Recently, Si-based solar cell efficiency reaches up 25.0%, which is approaching to Schockley-Queisser (S-Q) limit [1]. Thanks to the breakthrough of top-down nanotechnology, combining damage-free neutral beam etching (NBE) with bio-templates [2], high-quality Si superlattice becomes available to bring the intermediate band solar cell (IBSC) into possible. This novel photovoltaic cell combines two low-energy photons to generate a pair of high energy electron-hole pair to break the Schockley-Queisser (SQ) limit [3].

Our top-down nanotechnology can directly control the diameter, height, interdot space, and matrix materials, which brings higher flexibility of energy band engineering. Based on this advanced nanotechnology, we combine the quantum mechanism into macroscopic device operations to realistically design the Si-based IBSC for the first time. Firstly, the 3D finite element method was developed to calculate the electronic structure of realistic Si nanodisk superlattice; and then, we adopted Anderson model to calculate its' electrical conductivity; finally, by combining quantum mechanism into the detailed balance equation, we calculate various possible structures to maximize the conversion efficiency. The highest efficiency reaches 50.35% under full concentration, which is far higher than conventional Si solar cell. And the detailed efficiency contour plot can be used to balance process difficulty and conversion efficiency.

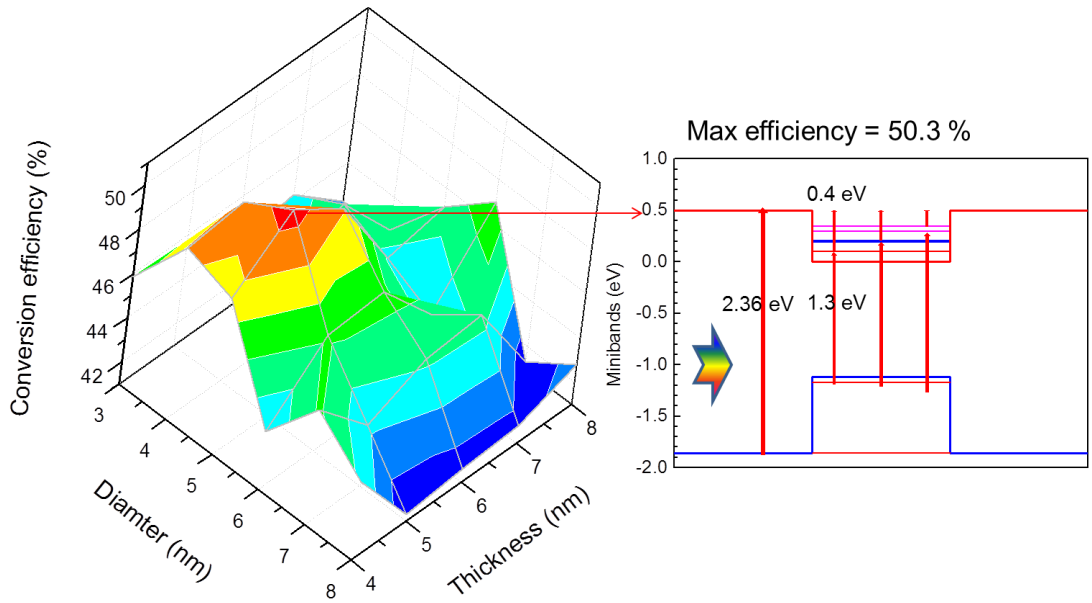

Figure The efficiency contour plot depends on the Si-ND quantum structures (Inter-dot space = 2 nm).

1. M. A. Green et al, *Prog. Photovolt: Res. Appl.* **2012,** 20, 606-614.
2. M. F. Budiman et al, *Nanotechnology* **2012**, 23, 065302.
3. Luque and A. Martí, Nat. Photonics 5, 137 (2011).
4. W. Hu et al, *Prog. Photovolt: Res. Appl.* DOI: 10.1002/pip.1208, 2011 (early view).