

ENGINEERING/TECHNOLOGY

Finite-Difference Time-Domain Simulation of Photovoltaic Structures Using a Graphical User Interface for MEEP

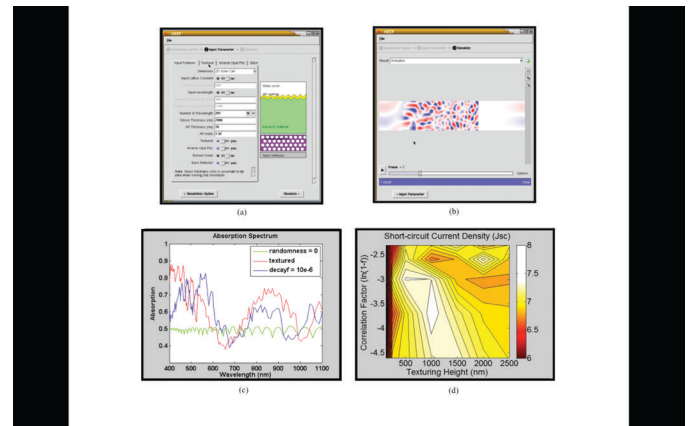
Student researchers: Xin Tze Tee, Junior

Interest in improving the performance and reducing the costs of photovoltaic (PV) cells is rapidly increasing. Novel thin-film PV cells offer the possibility of using less material, but require advanced light-trapping techniques for high performance. These designs must be carefully modeled; a finite-difference time-domain tool known as MEEP offers this capability for expert users. However, there is also great interest from new users in using MEEP for PV cells. Thus, we have developed a graphical user interface (GUI) for MEEP known as MEEPPV, geared toward simulation of 2D and 3D PV cell geometries, freely available through nanoHUB.org. The tool collects input from the interface to create a control file to run MEEP on the back end as before. It outputs images of the PV cell structure being simulated, plus transmission, reflection, and absorption graphs, as well as an animation of the fields propagating through the PV cell.

Our MEEPPV tool was subsequently used to examine and optimize the properties of surface texturing to improve light trapping in PV cells. We considered different feature sizes and numbers of randomly oriented blocks on the textured surface with and without an adjustable correlation factor and texturing height. This method demonstrates that a short-circuit current density J_{sc} of 7.466 mA/cm² was obtained at the optimum texturing height of 1000 nm and the correlation factor of 0.975 (24.6 % better than a flat surface). Our new, fully interactive tool provides

unique insights to researchers investigating nanophotonic structures for PV, and is freely available to the general public.

Research advisor Peter Bermel writes, "There is enough sunlight to power the world. To harvest it with solar cells, improving light trapping is a promising approach. However, it can be challenging for researchers to accurately model this behavior. This work will enable more researchers in solar to utilize advanced optical modeling through a user-friendly interface."



(a) Our solar cell schematics update in real time as each feature is selected; (b) Output animation depicting the propagation of fields in time throughout the computational cell; (c) Absorption spectrum for surface texturing with a correlation degree, $f = 0.975$ (red), with a smaller decay constant (blue), and with no surface texturing (green); and (d) Contour plot showing the short-circuit current density versus texturing height and the correlation factor. Optimal performance occurs when $f = 0.975$ and $h = 1000$ nm.

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