Topology Optimization Driven Design on Highly Efficient Thin Film Solar Cell, PS&ED 2012-2013

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MECHANICAL ENGINEERING, NANOTECHNOLOGY, PHOTOVOLTAIC DEVICES

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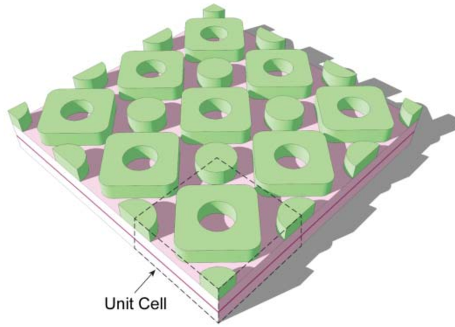
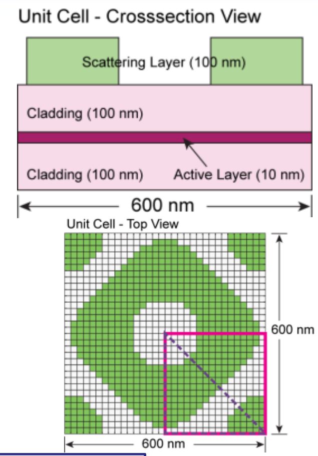
Project Objective:

Light trapping in thin-film solar cell is a highly complex physical phenomenon and imposes a number of challenges to topology optimization. The goal of this project is to develop a general, yet systematic approach exploiting topology optimization for light-trapping structure designs in solar cells. We implemented both genetic algorithm (GA) based non-gradient topology optimization (NGTO) and SIMP based gradient topology optimization (GTO) to achieve highly efficient solar cell designs. As a future work, a robust design method will be developed accounting for geometric uncertainty.

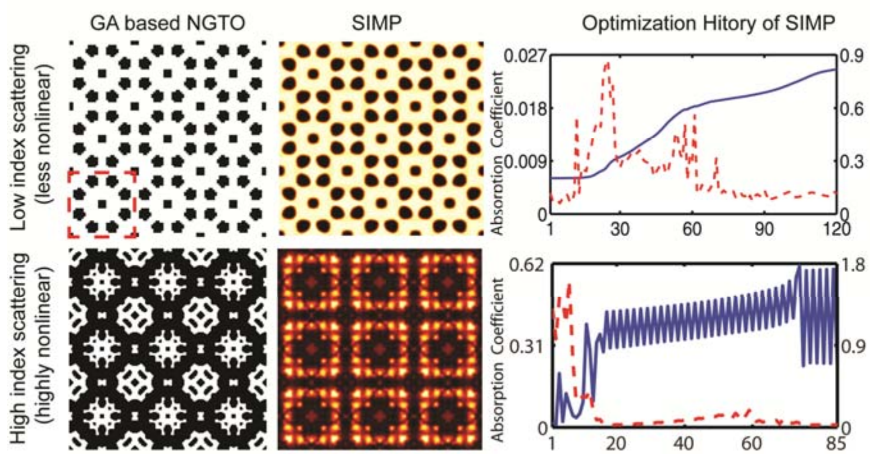
Test model:



- •Solar cell model: slot-waveguide based thin film solar cell [1].
- •Discretize the front scattering layer by 32*32. Design variables are each pixel.
- •Design objective is to maximize the absorption.

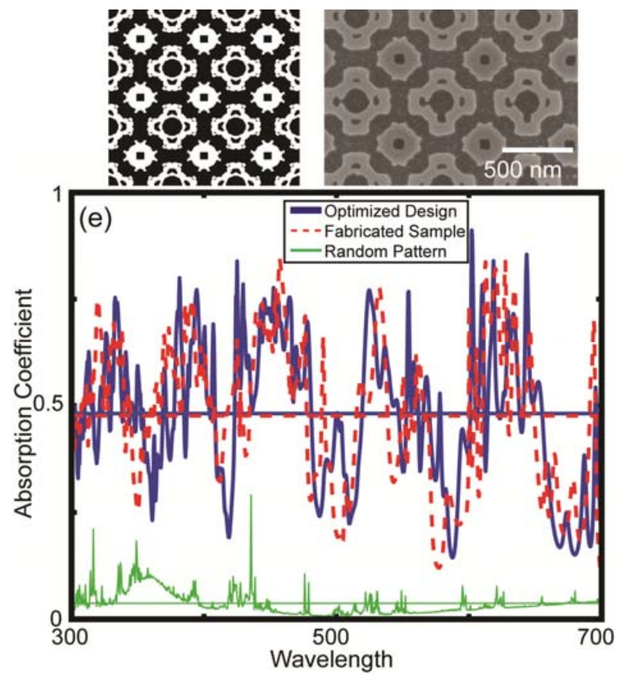


Single wavelength result & comparison of NGTO and SIMP



- •Both GA based NGTO and SIMP are conducted to optimize the absorption at incident wavelength λ=500nm.
- •Both GA and SIMP can handle the less nonlinear case; while SIMP fails at highly nonlinear case, which can be observed from the optimization history.
- •We also tried to improve the regularization scheme of the SIMP based approach. However, the results show that there is a fundamental challenge of using GTO approach for nanophotonic problems with high nonlinearity.

Broadband result: design & fabrication



- •The optimized structure achieves a broadband absorption efficiency of 48.1% and more than 3-fold increase over the Yablonovitch limit [2].
- •The fabrication feasibility is also demonstrated.
- •Robust design method will be developed to account for the fabrication imperfection

Acknowledgement: thanks for Fan's fabrication. The work is supported by NSF.

Ref: [1] Z. Yu, *A. Raman, S. Fan, PNAS*, 2010. [2] C. Wang, S. Yu, W. Chen, C. Sun, Sci. Rep. 2013.

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