A model for multi-resonant light absorption in ultrathin solar cells

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Lambertian light scattering is the reference model for light trapping. It can be obtained with random surface texturing and leads to an optical path length enhancement up to a factor $4n^2$ [1], with n the refractive index of the absorber. However, recent numerical studies have shown that this Lambertian limit can be overcome with different approaches.

Here we show how multi-resonant absorption can exceed the Lambertian limit. We have developed a model based on Fabry-Perot (FP) and Guided Modes (GM) resonances in a solar cell modeled as a simple 3-slab structure with a 2D array of nanostructures (figure 1). We will explain the key principles of this model (complex frequencies, perturbation approach) and show how the period, size, shape and symmetries of the nanostructures can be tuned in order to maximize the number of resonances and the absorption maximum of each peak.

Within this approach, we provide a simple recipe for the optimization of light trapping in solar cells. The final result is a multi-resonant absorption spectrum significantly above the Lambertian limit (figure 2). This strategy is particularly adapted to thin-film solar cells made of direct bandgap semiconductors, and sets a milestone for light confinement in nanoscale hot-carrier solar cells.

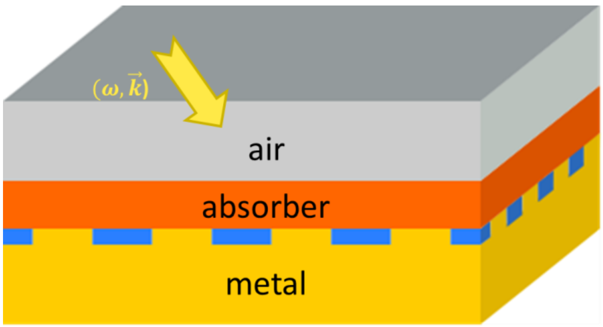

Figure 1: Structure considered for the computation

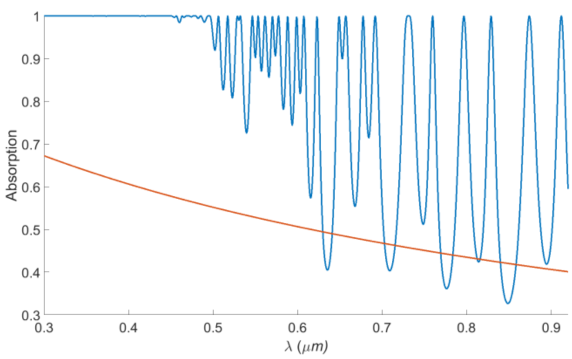

Figure 2: Comparison between our multi-resonant absorption model (blue) and the Lambertian limit (red)

[1] Yablonovitch, Eli, and George D. Cody. "Intensity enhancement in textured optical sheets for solar cells." *IEEE Transactions on Electron Devices* 29.2 (1982): 300-305.