Topology Optimized Nanostrips for Electric Field Enhancements

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This work addresses efficiency improvements of solar cells by manipulating the spectrum of sunlight to better match the range of efficient current generation. The intrinsic transmission losses in crystalline silicon can effectively be reduced using photon upconversion in erbium ions in which low energy photons are converted to higher energy photons able to bridge the band gap energy and contribute the energy generation. The upconversion process in erbium is inefficient under the natural solar irradiation, and without any electric field enhancements of the incident light, the process is negligible for photo-voltaic applications. However, the probability for upconversion can be increased by focusing the incident light onto the erbium ions using optimized metal nanostructures[1, 2, 3].

The aim of this work is to increase the photon upconversion yield by optimizing the design of metalic or dielectric nanostructures placed on top of an erbium doped thin film. To achieve this goal, topology optimization[4] is used to create 2D cross-sectional designs of nanostrips able to focus the incident light into the film. The infrared absorption band of erbium is sought utilized by optimizing for multiple excitation wavelengths while also including production inaccuracies directly within the optimization process[5]. The governing physics is modeled using Maxwell equations in a finite spatial domain truncated using periodic or scattering boundary conditions.

References

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