Optimization of Random Diffraction Gratings in Thin-Film Solar Cells Using Genetic Algorithms

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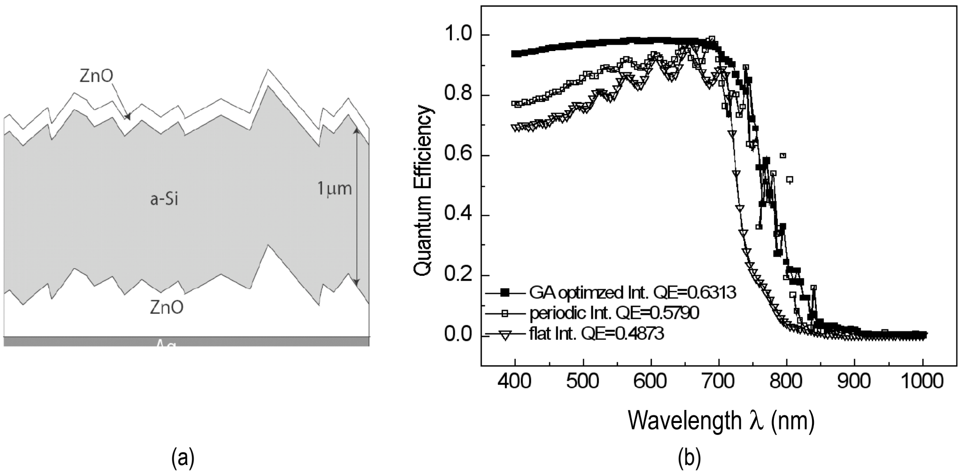

Schematic of (a) thin-film solar cell structure with textured surfaces, and (b) plot of quantum efficiency versus wavelength comparing planar solar cells to cells with periodic diffraction gratings and optimized gratings with randomized texture.

Thin-film solar cells are an emerging technology with potential for a low-cost renewable energy source. The primary limitation for these solar cells is the relatively low-conversion efficiency (approximately 15%). Due to its thin-film nature, the absorbance in these solar cells is weak at longer wavelengths where the absorption coefficient is low. To increase the conversion efficiency, back reflectors may be used in the solar cell structure. Many approaches have been implemented for these reflectors, including randomly textured surfaces and lithographically defined periodic gratings. The optimization of these gratings is a difficult task due to the broad solar spectrum. In this work, we examine the optimization of periodic gratings and textured surfaces for thin-film solar cells using Genetic Algorithms (GA). The optical absorption profile is calculated in the 400nm–1000nm wavelength range to determine the integrated quantum efficiency for the solar cell. Solar cells with optimized multi-level rectangular gratings exhibit a 23% improvement over planar cells, where cells with an optimized textured surface exhibit a 29% improvement over planar cells. The enhanced solar cell efficiencies for multi-level rectangular and arbitrary gratings are attributed to improved optical coupling and light trapping across the broad band solar spectrum.