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Graded-Index-Metamaterials PV cell

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Mini Review

Due to environmental problem with traditional source of fuel energy, energy policy makers are seeking for an environmental safe source of energy. Solar energy is the most promising type of renewable energy that is environmental friendly. It is abundant, safe, and free. Photovoltaic (PV) cell is the building block for a solar system. PV absorbs light and converted to electrical energy. Several works have been conducted to increase the efficiency of the PV. To decrease the reflection of light at the surface of the PV, antireflection coating (ARC) is used [1]. An important example of ARC is SiN_x for its high refractive index [2]. In addition, reseachers who are seeking minimum reflectance ar PV surface, intoduce new structure which involve metamaterial (MTM). Metamaterial is a noval material fabracted at laboratory with negative refractive index. They assume different refractive index by changing certain parameter as in [3-6].

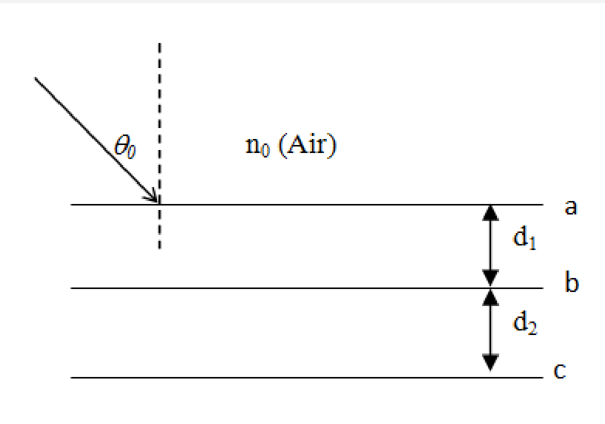

Figure 1: The schematic of the proposed nanostructure Solar Cell.

In this work, a new PV structure is proposed. Figure 1 displays the schematic of the proposed PV that consists of SiN_x thin film deposited on glass and covered by MTM bounded by air. The refractive indices are n_0, n_1, n_2, and ns for air, MTMs, SiN_x and glass respectively. MTM layer is assumed to have graded index with thickness d1. SiNx has refractive index, which can assumed different values depending on the doping ratio, has thickness is d_2. The light is assumed to shine on the PV at oblique incidence with different incidence angle (θ_0).

For oblique incidence, the optical reflectance and admittance for the k^{th} layer including negative index materials with graded index is derived in the paper of [7-8] for both transverse electric field polarization (TE) and transverse magnetic field polarization (TM). The total reflectance R for the solar cell is defined as the average of both values R^{TE} and R^{TM}

$$R = \frac{R^{TE} + R^{TM}}{2} \quad (1)$$

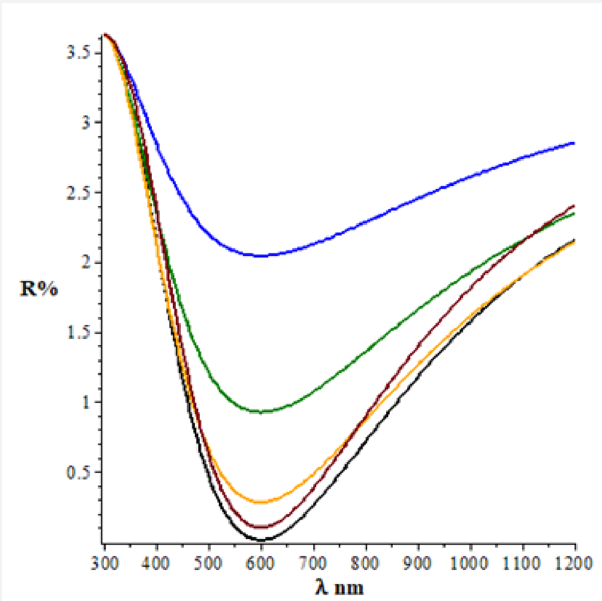

Figure 1: The reflectance calculated for n_1=-2+ Δ(λ), under normal incidence. The red, black, yellow, green and blue curves correspond to n_2=2.5, 2.4, 2.3, 2.2, and 2.1 respectively.

Equation (1) is solved numerically using the software Maple 13 to verify the characteristics of the proposed PV cell. The thicknesses d_1 and d_2 are taken to be equal the quarter wavelength at each media. The spectral response of SiN_x goes from 300-1200nm [3]. Thus, this range is taken to limit the spectrum of the incident light. In the calculation, only normal incidences considered. Figure 2 exhibits the total reflectance Rat different values of n_2: 2.5, 2.4, 2.3, and 2.2 and MTM has n_1=-2+ Δ(λ). We notice that the spectral takes zero value when n_2=2.4 for λ aound 600nm and all other curves maintain a reflectance lower than 2.3%. Comparing our result with one or two ARC layers in Beyer calculations [3]. We obtain a better result since his system maintained reflectance fewer than 5%.

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