Simulation of Antireflection Coatings System Based on DLC/Porous Si and TiO_2/SiO_2 for Si Solar Cells

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The exploitation of diamond-like carbon (DLC) films in a wide range of practical applications attracts scientific interest [1]. More than 35% of solar radiation reflects from the surface of a silicon solar cell. This phenomenon negatively affects the quantity of generation of electron-hole pairs. Inhibiting of reflection can be achieved by applying anti-reflection coatings (ARC) on the silicon surface, with refractive indices n between n = 1 (Air) and n = 4.0 (Si). In the visible spectrum n = 1.5–3 for porous silicon, n = 2.4 for the DLC film, n = 1.5 for SiO_2 and n = 2.1–2.5 for TiO_2 [2]. By changing the thickness of the layers, the minimum of Inhibiting can be shifted to different parts of the spectrum. The deposition of two-layer films allows for expanding the useful range. A porous silicon layer has important advantages: the textured surface, the possibility of changing the bandgap, the ease of manufacture of the layer, and the variation of the refractive index by electrochemical anodization. Silicon DLC films are characterized by high mechanical, chemical, and radiation resistance.

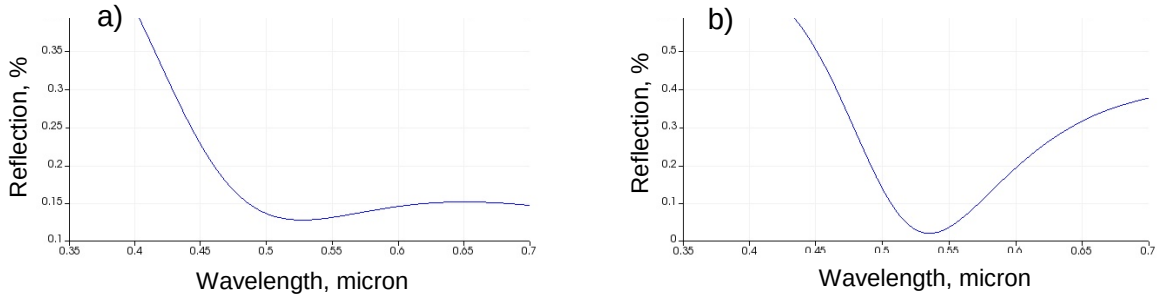

Figure 1 - Reflection spectra of a) DLC/Porous Si/Si and b) $TiO_2/SiO_2/Si$ obtained using the Lumerical FDTD program.

The modeling of the reflection coefficient with a commercial simulation base revealed the optimum ratios of the thicknesses d of the DLC/Porous Si and TiO_2/SiO_2. Encouraging results were obtained with the following layer parameters: n(DLC) = 2.4, d(DLC) = 90 nm; and n(PS) = 2.2, d(PS) = 50 nm. Reflection in a wide range of 500–700 nm was about 10% (Fig. 1a). The following parameters were obtained for the two-layer TiO_2/SiO_2 system: n(TiO_2) = 2.1, d(TiO_2) = 150 nm; n(SiO_2) = 1.5, d(SiO_2) = 90 nm. The reflection was less than 1.5% in the range of 500–550 nm (Fig. 1b). It is possible to significantly reduce reflection and increase the efficiency of solar cells.

References

[1] Beisembetov I.K., Beisenkhanov N.B., Dochshanov A.M., Zharikov S.K., Kenzhaliev B.K., Nussupov K.Kh. Sintez plenok so strukturoy tipa almaza (S, SiC) na kremnii osazhdeniyem libo implantatsiyey ionov 12C (Synthesis of films with a diamond (C, SiC) like structure on silicon by deposition or implantation of 12C ions)//Vestnik NNGU. Nizhniy Novgorod. №3 (1). 2011. S. 50-55.
[2] https://refractiveindex.info/