1D Photonic Crystal for Solar Cell Applications

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Many efforts have been done to improve light trapping in solar cells by reducing the reflectance on the top surface [1-3]. Even though new technologies are coming up [4-6], silicon solar cells are the most widespread type of solar cell in the current market so improving their efficiency is still interesting. In this work, a very easy method to pattern 1D photonic crystals (PC) on silicon solar cells to improve the light trapping is presented.

Several PCs have been simulated using OptiFDTD software with the objective of choosing the best structure to reduce the reflectance at the silicon surface. To minimize the number of simulations, a Design of Experiments (DOE) technique has been used to study the relationship between the reflectance of the surface and the PC´s dimensions (p, a, h). With DOE, three sorts of structures have been studied obtaining the optimum dimensions for each kind of PC. A diagram of the different PC studied in shown in Fig.1. Simulations have concluded that rectangular PCs have lower reflectance than the others types.

Several rectangular PCs have been fabricated with Laser Interference Lithography (LIL) and Reactive Ion Etching (RIE). LIL is a method to easily pattern large areas (in the range of 10cm diameter) with nano-gratings or nano-grids [7] on a photoresist. The tool used for this work is known as “Lloyd’s Mirror” and uses the interference of a coherent laser beam. Images of fabricated PCs obtained with Scanning Electron Microscope (SEM) are shown in Fig.2a) and b). The reflectance of this fabricated PC has been measured with a spectrophotometer and compared with simulation results. One example is shown in Fig.3, where the good agreement between both data can be seen.

In summary, 1D PCs can be easily patterned in large areas to reduce the reflectance on silicon solar cells. The pattern could be done on others substrates, so this improvement could be applicable to others types of solar cells. Also, different structures could be done in the future with this method to reduce even more the reflectance.

References

[1] C. Eisele, C. E. Nebel and M. Stutzmann, Journal of Applied Physics (2001) Vol. 89, No.12
[2] H.Stiebig, N.Senoussaoui, T. Brammer and J. Müller, Solar Energy Materials & Solar Cells 90 (2006), 3031-3040
[3]P. Bermel, C.Luo, L.Zeng, L.C.Kimerling and J.D.Joannopoulos, Optics Express (2007) Vol.15, No.25
[4] D. Wei, Dye Sensitized Solar Cells, Review (2010)
[5] I. Prieto, B. Galiana, P.A Postigo, C.Algora, L.J.Martínez, and I. Rey-Stolle, Applied Physics Letters 94, 191102-1 (2009)
[6] S.B Mallick, M. Agrawal and P.Peumans, Optics Express (2010) Vol. 18, No.6
[7] H Smith, Physica E 11 (2001) .104-109.

Figures

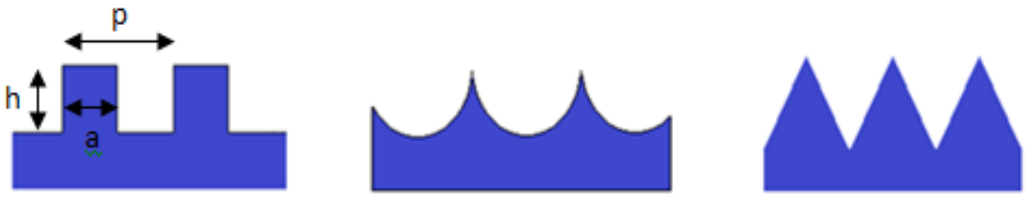

Fig.1 1D Types of PC studied.

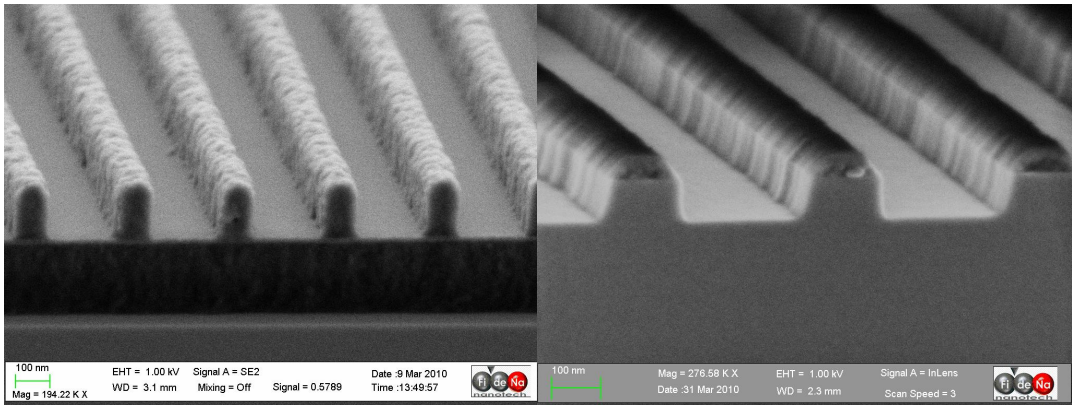

Fig.2 a) Pattern transferred to the photoresist on top of an anti-reflecting layer and the Si. b) Transference of the pattern to the Si of the substrate by RIE.

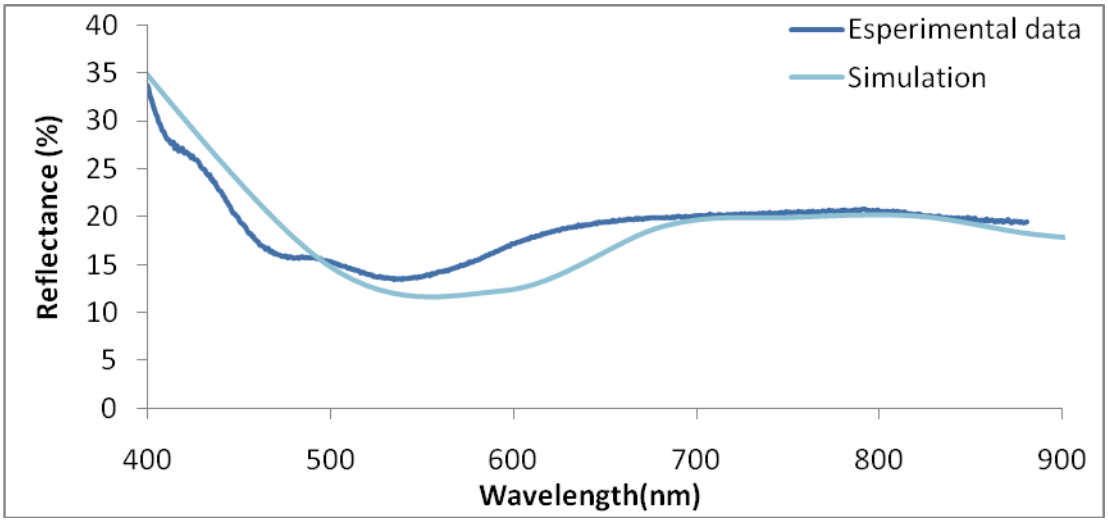

Fig.3. Comparison between simulation and experimental measurements for a rectangular PC.