Shell thickness effects on core-shell c-Si/a-Si nanopillar solar cells

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***Abstract*—The light harvesting properties have been numerically investigated in c-silicon/a-silicon core-shell nanopillar array. The influence of shell thickness on optical absorption versus different core diameter has been thoroughly analyzed by using finite-difference time-domain (FDTD) simulations. It is found that a-silicon shell significantly enhanced infrared absorption especially for smaller diameter nanopillar. As a result, the core-shell nanopillar device exhibits a absorption enhancement from 0.22 to 0.65 at 800nm and from 0.05 to 0.43 at 1000nm. Furthermore, the mechanism of the absorption has been discussed.**

***Keywords*-silicon solar cell; nanopillar; core-shell structure.**

I. Introduction

Silicon is the workhorse of the modern semiconductor industry due to its non-toxic, biocompatible and stable characteristics when it comes to device performance. During the past several years, much effort is devoted into replacing existing non-renewable power using silicon solar cell. In order to harvest light efficiently, most commercialized c-silicon solar cells need at least 150 μm substrate. On the other hand, thin film silicon solar cell can both achieving materials saving and procedures simplification. Great efforts have been invested on performance improvement for silicon thin film solar cells. Recent studies on front surface texturing of silicon nano-structures array, such as nanowires [1], nanopillar [2-3], nanoholes and nanocones, have excellent light trapping properties, which provide various solutions for boosting the light harvesting on silicon thin film.

Moreover, radial p-n junction with the pillar structure allow decouple light trapping along the wire axis and the carrier collection along the radial direction which shows great application potential. Previous research shows that c-silicon nanopillar has strong enhanced light absorption compared to planar silicon device. However, the strong absorption rapidly diminished for the long wavelength light due to the indirect bandgap nature of c-silicon [4]. Hence, c-silicon/a-silicon core-shell nanopillar arrays can be achieved high absorption for long wavelength light, in which amorphous Si shell is considered to have a direct bandgap.

In this paper, we numerically study the optical properties of c-silicon/a-silicon core-shell, by employing the rigorous finite-difference time-domain (FDTD) method. The impact of sell thickness in different diameter nanopillar array is presented.

II. Structure and modeling

In Figure.1, we show the schematic drawings of c-Si/a-Si core-shell nanopillar array on 1μm c-silicon substrate. The parameters of the Si nanopillar are represented by the diameter (*d*), the height (*h*) and the periodicity (*P*). The thickness of a-silicon shell was selected as 0nm, 5nm and 20nm. Numerical simulations are performed using the FDTD package. Periodic boundary conditions are used in the x and y directions, and perfectly matched layer boundary conditions are used in the z direction. A normally incident electromagnetic wave within wavelength form 300nm to 1100nm, illustrates the nanopillar along the z axis.

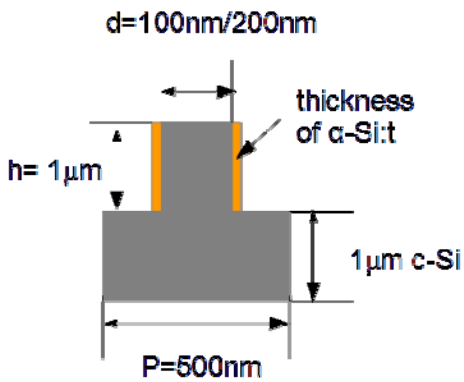

Fig. 1. Schematic of the c-Si/a-Si core-shell nanopillar array on c-silicon substrate

III. Results and discussion

Fig.2 and Fig.3 show the Absorption spectrum for c-Si/a-Si core-shell nanopillar array versus diameter. Due to the high absorption coefficient of a-silicon, the adsorption greatly increased with the increase of shell thickness.

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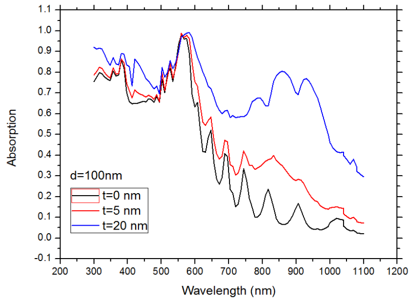

Fig. 2. Absorption spectrum for c-Si/a-Si core-shell nanopillar array at d=100nm

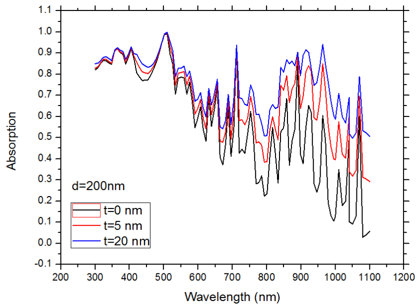

Fig. 3. Absorption spectrum for c-Si/a-Si core-shell nanopillar array at d=200nm

Fig.4 and Fig.5 show the electric intensity distribution versus diameters at wavelength at 300nm, 600nm, 800nm and 100nm respectively.

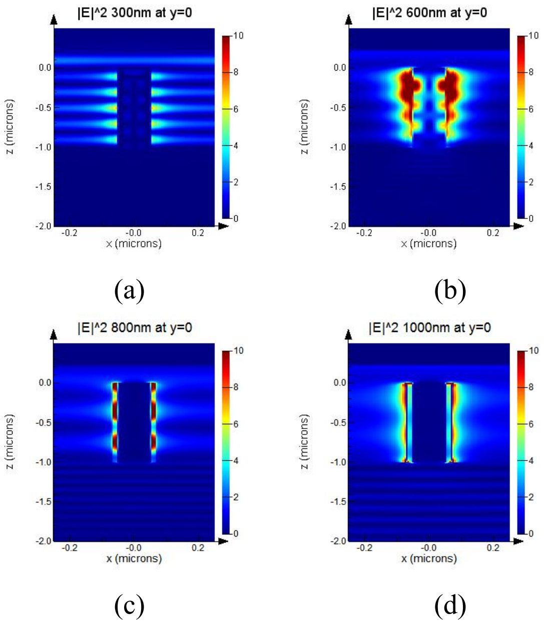

Fig. 4. Electric intensity distribution at the cross section for c-Si/a-Si core-shell nanopillar array at d=100nm t=20nm (a) λ=300nm (b) λ=600nm (c) λ=800nm (d) λ=1000nm

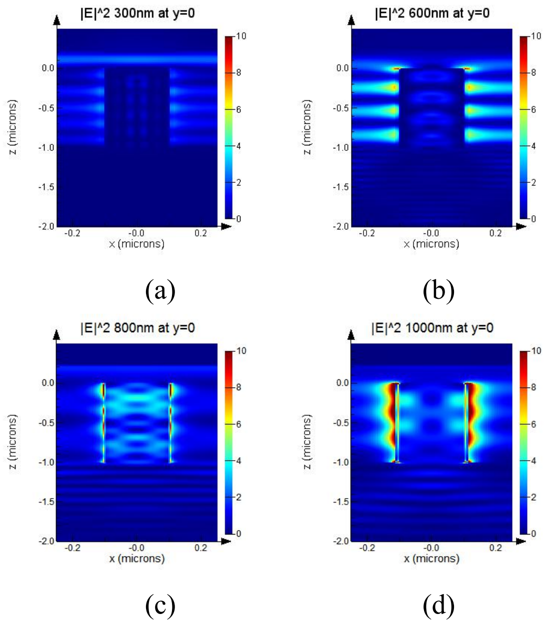

Fig. 5. Electric intensity distribution at the cross section for c-Si/a-Si core-shell nanopillar array at d=200nm t=20nm(a) λ=300nm (b) λ=600nm (c) λ=800nm (d) λ=1000nm

We have shown that shell thickness has more apparent effect in smaller diameter nanopillar. Thees impact mainly attributed to the nanostructural benefits which can greatly enhance the long wavelength region.

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