Study of the optical properties of a micro pillar array solar cell for different configurations

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Abstract- **In this paper, we report the optical properties of a Silicon (Si) solar cell when varying the configuration (hexagonal and square) of a micro pillar array on the cell surface using the FDTD technique. It was found that the hexagonal configuration gives better performance.**

INTRODUCTION

Light trapping of the solar incident light can be achieved by texturing the solar cell surface. There are various techniques available such as: placing nanowires [1], micro pillars [2], etc on the cell surface. In this paper, Silicon (Si) micro pillar arrays in Hexagonal (HEX) and Square (SQ) configurations were studied by the FDTD technique [3].

A schematic of the simulation set up is shown in Fig. 1. A Si micro pillar array was placed on the surface of the Si substrate. A plane wave source produces the reference solar spectrum AM 1.5. The Reflectance was obtained from a plane monitor placed 0.3 µm above the source (receiving only reflected waves) and in parallel to the surface of the micro pillar arrays.

The Perfectly Matched Layer (PML) boundary condition [4] was applied to terminate the numerical window, to absorb any stray radiation. However, on the remaining boundaries (i.e. at the sides), Periodic Boundary Conditions (PBC) were applied. By applying this type of boundary condition an infinite array of Si micro pillars is simulated.

The parameters to be varied for these simulations were: micro pillar array configurations and surface coverage.

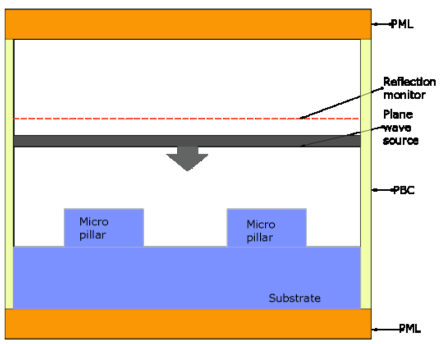

Fig.1 Schematic of the simulation set up

RESULTS

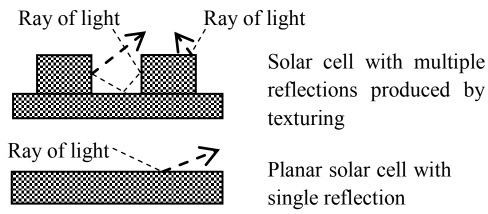

Fig. 2 Diagram explaining multiple reflections

The purpose of placing micro pillar arrays on the surface of a solar cell, is to trap the light in the area between the pillars by multiple reflections (see Fig.2).

Figure 3 shows the Reflectance as a function of the wavelength for hexagonal and square configurations for a surface coverage of 60 %. We can clearly see that the micro pillar array solar cells give better performance than the planar cell. At this surface coverage (60% as shown in Fig. 3), the performance of the hexagonal configuration is shown to be better than the performance of the square configuration.

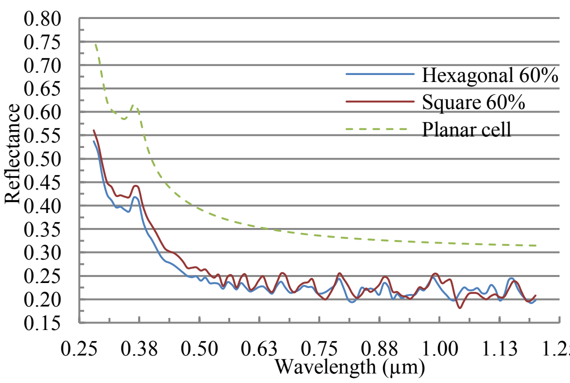

Fig. 3 Reflectance as a function of wavelength (µm) for the planar cell and cell with micro pillars (Height = Diameter = 2 µm) in HEX and SQ configurations

To further explore this, we show in Fig. 4 the Reflectance integrated over all wavelengths plotted as a function of surface coverage. From this figure, we can see that the Reflectance has a significant variation with change in surface coverage.

When the surface coverage is low (i.e. 20%), the area between the pillars is large. This allows the majority of the sun light to leave the area between the pillars with no multiple reflections. If however, the surface coverage is large (i.e. 80%), the area between the pillars is very small. This allows the majority of the sun light to be reflected at the top of the micro pillars. For an optimum value of surface coverage, in between these limits, the light can be trapped by multiple reflections leading to lower Reflectance. From Fig. 3, it can be seen that a surface coverage of 60% is the optimum for hexagonal and square configurations.

The difference, in the Reflectance, shown in Fig. 4 is due to a higher concentration of pillars for the same surface coverage in the hexagonal configuration. In this configuration, the pillars are located on the most likely trajectory of the reflected rays. As a consequence more multiple reflections takes place, giving a lower Reflectance.

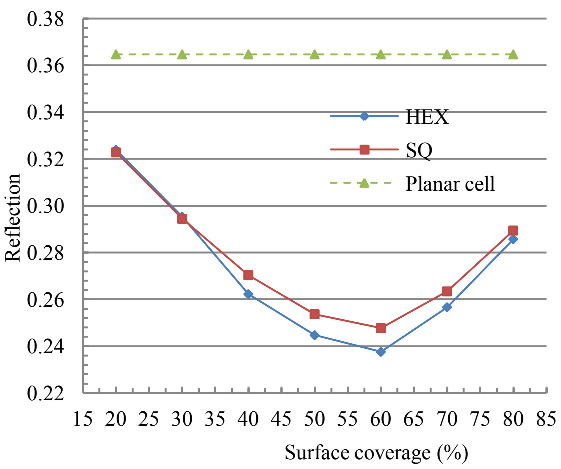

Fig. 4 Reflectance as a function of wavelength (μm) for the planar cell and cell with micro pillars (Height = Diameter = 2 μm) in HEX and SQ configurations

CONCLUSION

In this work, we have compared the performance of two micro pillar arrays configurations. From this analysis it is clear that the hexagonal configuration gives a better performance. This can be useful during the design process of a textured solar cell.

REFERENCES

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