FABRICATION OF ORDERED SILICON NANOROD-ARRAY AND SOLAR CELL APPLICATION

Shu-Fen Hu[1]* and Ching-Yang Wu[2]

[1]Department of Physics, National Taiwan Normal University
[2]Institute of Electro-optical Science and Technology,
88, Sec. 4, Ting-Chou Road, Taipei 116, Taiwan

Introduction

Silicon is the important materials in semiconductor, because it is abundant materials in the world. Today, the silicon nanowire or nanorod is intensively investigated with many fabrication methods [1]. The structure has applications of light-emitting devices [2], field-effect transistors [3], chemical sensors and solar cells [4-6]. The nanorod and nanowire has different electrical and optical properties due to their special structure. Moreover, a strong broadband optical absorption has been measured and discussed for silicon nanorods on substrate, which makes these nanorods an interesting candidate to serve as an absorber in solar cells [7]. The silicon nanorod structure was fabricated by various methods such as vapor-liquid-solid (VLS) growth method [8], metal catalytic etching[11], thermal evaporation oxide assisted growth and lithography related technique. But the density of silicon nanorods fabricated from VLS growth method were too low [4]. It's the main reason to lower efficiency for silicon nanowire solar cells.

In this paper, we demonstrated fabrication of silicon nanorod array by dry etching and lithography technique. The etching method may fabricate direct nanorod array structure from the surface of silicon substrate as shown in Fig 1.

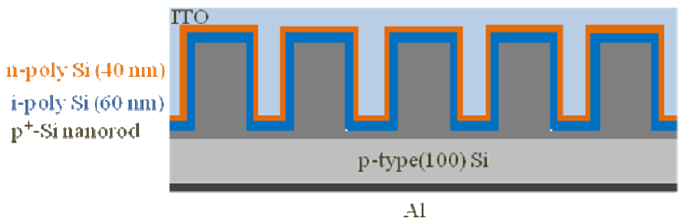


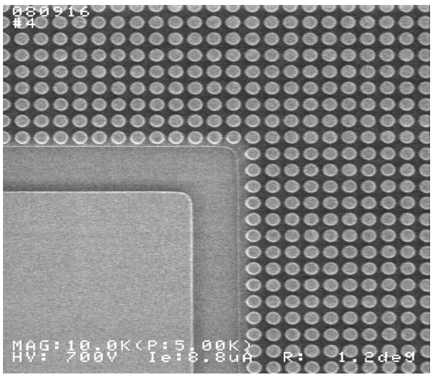
Fig. 1 Schematic of Si nanorods solar cell cross-sectional structure.

Experimental

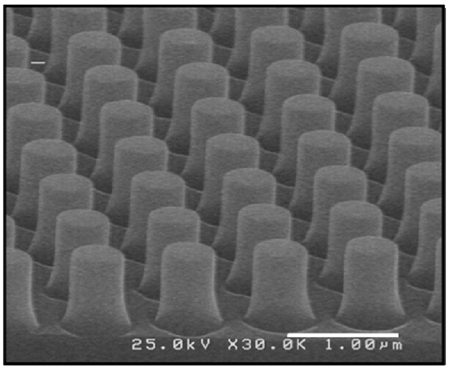
The ordered silicon nanorods arrays with diameters of 400-500 nm on *p*-Si (100) substrate were made by lithography technology and dry etching process. Polycrystalline Si (poly-Si) thin films which including 60 nm intrinsic Si and 60 nm n-type Si were deposited on the surfaces of nanorod array using low pressure chemical vapor deposition (LPCVD) by tube furnace. And then, the Al layer and In_2O_3: Sn was deposited by physical vapor deposition (PVD) on the back side and top side as contact metals.

Results and Discussion

Figure 2 shows (a) top (b) side view of scanning electron micrographs of silicon nanorod array on p-type silicon substrate. The nanorod diameter is 450 nm for *n-p*$^+$ junction and *n-i-p*$^+$ junction, respectively. It can be seen that the silicon nanorod array are perfectly straight and shipshape from semiconductor lithography fabrication. It's also found that the distances between each nanorods of *n-i-p*$^+$ junction is shorter than *n-p*$^+$ junction because additional inserted *i*-poly Si-layer for *n-i-p*$^+$ junction structure.



(a)



(b)

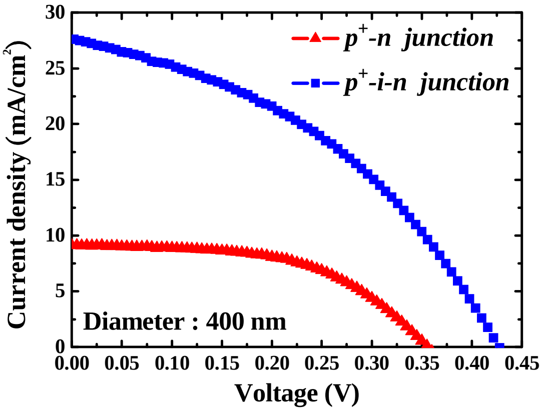
Fig. 2 Scanning electron micrograph (a) top view, and (b) side view of p^+-contact of silicon nanorods solar cell structure.

Figure 3 shows typical I-V curves of n-p^+ and n-i-p^+ junction of silicon nanorod array solar cells for (a) 400, (b) 450 and (c) 500 nm in diameters. Clear rectifying behavior is observed in these solar cell devices with 9.13 and 27.6 mA/cm^2 short current density for n-p^+ and n-i-p^+ junction with 400 nm silicon nanorod diameter. Here the short current density of n-i-p^+ junction is ~3 times than n-p^+ junction that are related with carrier injection.

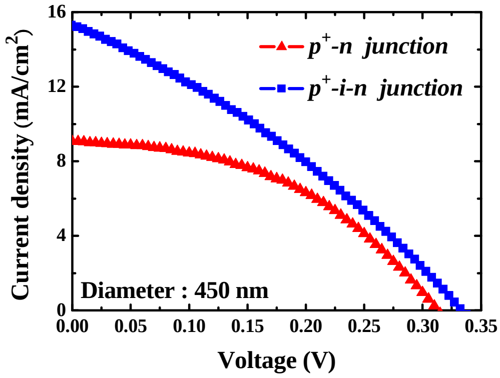
Conclusions

We have demonstrated the ordered silicon nanorod array with different diameters (400, 450 and 500 nm) and applied to n-p^+ and n-i-p^+ junction solar cell devices. The ordered silicon nanorods are fabricated by dry etching technique on the *p*-type silicon wafer. The highest short current density of solar cell devices were 27.6 mA/cm^2 and all efficiency 4.73% for n-i-p^+ junction structure solar cell with 400 nm in diameter. Our devices showed higher short current density by intrinsic poly-Si layer inserted. Contact optimization will be important to improve the solar cell device performance.

(a)



(b)



(c)

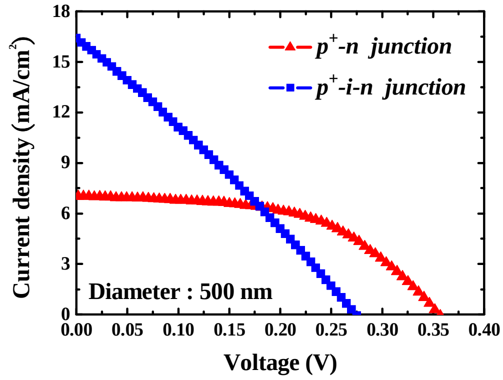


Fig. 3 I-V curve for different Si nanorod diameters of solar cells: (a) 400 nm (b) 450 nm (c) 500 nm.

Acknowledgement

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