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Improvement of Silicon Nanowire Solar Cell Properties

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In recent years, with enormous advantages of carrier collection and light absorption, Si nanowire (SiNW) solar cells offer a potential to replace the bulk silicon solar cells. To improve the performance of SiNW solar cells, better anti-reflection and more p-n junction areas are essential to pursue. A new metal catalyzed electroless etching (MCEE) method with a SiO_2 layer by UV/Ozone treatment [1], could obtain better nanowire arrays due to good uniformity and higher fill ratio nanowire arrays. In addition, to get a good metal contact with the front surface, all of nanowires were embedded in the p-Si matrix [2]. However, the reflectance was increased due to the embedded structure. To solve this problem, a selective etching method is being investigated [3] in this study, which is protecting the metal electrode area by photolithography.

SiNW arrays were formed by MCEE on 525 μm-thick n-type crystalline Si (100) substrates. UV/Ozone treatment was done before the MCEE process to form a thin layer of SiO_2. For the selectively etching process, first, photoresist layer was spun on the surface of silicon substrate, then Photolithography technique was used to develop the selective area for etching. Next, all samples were put into CVD chamber to fabricate solar cell junction by deposition of the B-doped p-type Si shell layer. Finally metal contact was made by sputtering.

Fig. 1 (a) shows the reflectance of silicon substrate with nanowire sturctures(green and blue curve) which have a lower reflectance than the untreated wafer(red curve). Furthurmore, an obvious reflectance reduction after the UV/Ozone treatment suggests MCEE with a SiO_2 layer could get a better nanowire arrays. SEM images in Fig. 1(b) reveal the UV/Ozone treatment increases the density of SiNW array by forming a SiO_2 layer. Next, Fig 2(a) shows a top-view SEM image of selectively etched Si substrate surface done by a photolithography technique. Fig 2(b) shows the cross-sectional SEM image. This technique makes it easier to form a better metal/semiconductor contact without increasing the reflectance after CVD core-shell growth.

References [1] Bai, F., et al., Journal of Nanoparticle Research (2013), 15(9).

[2] Mrinal Dutta, Naoki Fukata, Nano Energy (2015) 11,219-225

[3] Kumar, D. et al., Solar Energy Materials and Solar Cells (2011) 95(1), 215–218.

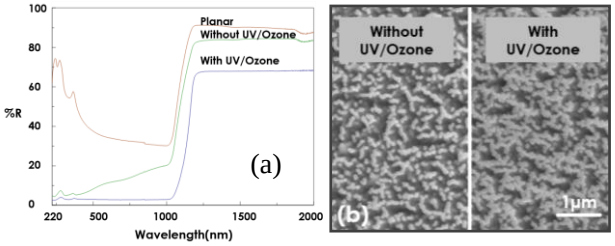

Fig. 1(a) Reflectance spectra from 220 nm to 2000 nm (b) SEM images of nanowires with and without UV/Ozone treatment.

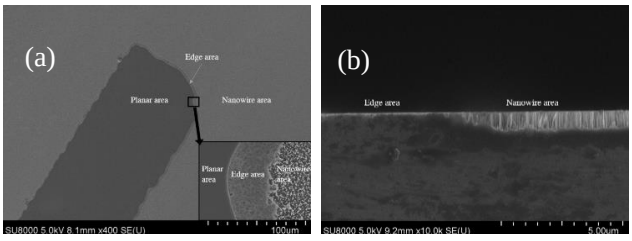

Fig. 2 (a) Top and (b) cross-section view of SEM image of selectively etched silicon substrate.