Elaboration and Characterization of Black Silicon for Photovoltaic Solar Cells

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ABSTRACT

In this work, the optical and morphological properties of black silicon (b-Si) have been investigated. The b-Si was fabricated by Metal-Assisted Chemical Etching (MACE) method. Two-step MACE process was deployed to produce b-Si nanostructures by using silver (Ag) as acatalyst. The b-Si was elaborated with and without KOH post-etching, and the samples prepared without KOH treatment exhibited the lowest average weighted reflectance (AWR) and the highest absorption, especially in violet and near infrared wavelength regions. The SEM images of samples post-etched by KOH solution show the formation of square-like nanostructures with a size varies in the range 20 - 200 nm. While the samples containing b-Si without treatment by KOH solution showed nanostructures with other shapes and different sizes.

Introduction

As a widely used semiconductor material, silicon has been extensively used in many areas, such as a photodiode, photodetector, and photovoltaic devices.However, the high surface reflectance and large bandgap of traditional bulk silicon restrict the full use of the solar spectrum, especially in photovoltaic application. To solve this problem and improve the photon absorption of this material, many methods have been developed. Amongthem, nanotextured silicon surface, so-called black silicon(b-Si), is an excellent path to minimize the light losses in the front of solar cells. It absorbs light very efficiently for a wide range of wavelengths, and as a result, it appears black to the naked eye. In this work, we investigated the surface morphological and the optical properties of b-Si wafers fabricated by the MACE technique by using Ag as a catalyst[1,2].

Experimental

The black silicon was fabricated by the Metal-Assisted Chemical Etching (MACE) technique. The two-step MACE process was deployed to produce nanostructures through silver (Ag) used as a catalyst. The MACE etchingprocess duration has been optimized to be 60 min. After the fabrication of b-Si, some samples were treated by theirimmersion in KOH solution for 10 s and 50 s, and the obtained results were discussed according to the effect of KOH and the immersion time. The samples characterization was carried out by high resolutionScanning Electron Microscope (SEM) as well as by UV- Vis Spectrophotometer.

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Results and Discussion

Fig.1 illustrates an example of the findings. It shows that b-Si without KOH treatment exhibits nanostructures with

the lowest reflectance especially in violet and near infrared regions, with an average weighted reflectance(AWR) of 8.32%. The use of KOH increases AWR value to 8.98% and 10.97% when the immersion time is 10 s and 50 s, respectively. The improved light absorption for the samples prepared without KOH treatment can be explained by the refractive index gradient yields from the changing of material density in nanometric scale. On the contrary, the samples treated by KOH solution demonstrated the creation of square-like holes as shownin the right inset of Fig.1 (i.e. MEB image). The size of these holes varies between 20.5 nm and 208 nm, and theirlight absorption is less efficient than that associated to the samples without KOH treatment.

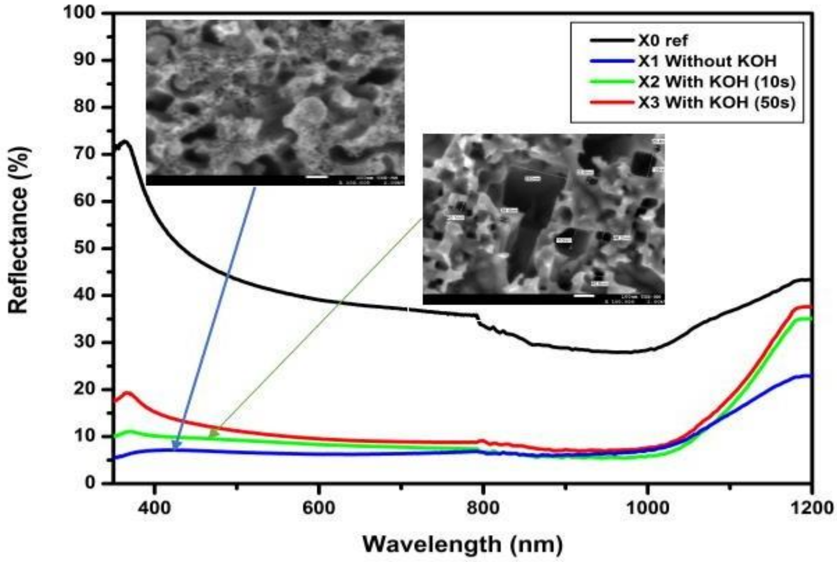

Fig.1: Reflection spectra of black silicon (b-Si) without and with KOH treatment for 10 s and 50 s, compared to the spectrum of silicon with plan surface. The insets are the SEM images of b-Si without and with KOH treatment.

Conclusion

This investigation showed the effect of KOH etching on the properties of b-Si and its importance to control thesize of the nanostructures. This control is an important step in the photovoltaic technology, because it leads to an efficient light management in the solar cells.

Acknowledgments

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