FORMATION OF BLACK SILICON USING THE SIGE SELF-ASSEMBLED ISLANDS AS A MASK FOR SELECTIVE ETCHING

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Modern trends in the field of crystalline silicon photovoltaics, in particular, the fabrication of thin-film Si solar cells, require the development of new approaches for formation of the so-called “black silicon” (BSi): silicon with small reflection (R) in a broad wavelength range and the large fraction of absorbed photons [1].

In this paper we proposed the method for fabrication of BSi using the selective wet etching of structures with GeSi/Si(001) self-assembled islands.

The initial structures for formation of BSi were the single side polished Si(001) wafers with SiGe self-assembled islands on the top. Islands were obtained with the help of Ge deposition by MBE. The parameters of islands growth were optimized in order to achieve the lateral sizes of islands comparable with the wavelengths range of visible and near IR light. As a result the SiGe islands were plastically relaxed and had the typical sizes which are much larger than of the coherent Ge(Si) self-assembled quantum dots [2]. It should be noted that the growth procedure is quick, simple and can be easily adopted for industrial CVD growth on large scale Si wafers.

Submicron relief on the Si surface was created by selective etching of silicon at room temperature in an aqueous solution of KOH with the addition of an isopropyl alcohol (KOH + IPA solution). At such conditions SiGe islands act as a mask for the anisotropic etching of Si. After the relief formation islands were removed from the surface by selective etching of SiGe alloy in HF:H₂O₂:CH₃COOH solution. According to SEM and AFM images the Si surface after such sequential etching possess a characteristic submicron relief (Figure 1), which parameters can be controlled by changing both growth and etching conditions. It should be noted that the thickness of Si layer which is removed during the relief formation is less than 1 μm.

The fabricated surface relief allows to reduce the value of R from Si in the wide spectral range by almost an order of magnitude in comparison with the surface of an initial Si wafer (Figure 2). As a result the weighted reflectance from such BSi in the wavelength range of 500-1200 nm is only 2–3%. Together with the observed increase in absorption of light with λ > 900 nm due to light scattering, this leads to a significant increase of the absorption of visible and IR radiation.

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Figure 1: SEM images of Si surface after etching of structures with SiGe islands in KOH+IPA and HF: H₂O₂:CH₃COOH

Figure 2: Reflection from the initial Si wafer, from structure with SiGe islands and the same structure after the sequential etching in KOH+IPA and HF: H₂O₂:CH₃COOH solutions.