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Ultra-low reflectivity poly-crystalline Si surfaces fabricated by surface structure chemical transfer method

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For achievement of high efficiency solar cells, formation of ultra-low reflectivity surfaces is indispensable. Polycrystalline Si can provide a low cost starting material as compared to crystalline Si, however, low reflectivity surfaces cannot be produced by isotropic alkaline etching due to the presence of various crystal orientations. Therefore, acid etching is usually employed to produce rough surfaces, but the reflectivity is still higher (i.e. ~ 20%) than that of mat-textured surfaces (i.e. ~ 10%) by alkaline etching.

We have developed a method for producing ultra-low reflectivity Si surfaces using the “surface structure chemical transfer” (SSCT) method. A nanocrystalline Si layer can be produced on the polycrystalline Si surface simply by contacting with a catalyst in an HF-H_2O_2 solution. Surface SEM (Figure 1a) micrograph reveals the formation of nanocrystalline Si of about 20 nm diameter. Cross-sectional TEM (Figure 1b) shows that the thickness of the nanocrystalline Si layer formed on the polycrystalline Si is 100 - 150 nm. Reflectivity data of the polycrystalline Si surface before and after the production of the Si nanocrystalline layer is shown in Figure 2. The reflectivity of the polycrystalline surface with a Si nanocrystalline layer (Figure 2b) was observed to be as low as 2% in the 300 – 800 nm wavelength region. The reflectivity for the mat-textured Si surface (Figure 2c) formed from Si(100) is also shown for reference which is about 10% - 40%. Photoluminescence measurements showed an emission peak at 670 nm, indicating band-gap widening for the nanocrystalline Si. Minority carrier lifetime measurements showed an increase in lifetime from about 1 μs to 5 μs, possibly as a result of prevention of recombination of electrons and holes at the nanocrystalline Si / Si interface by the energy barrier present at the interface.

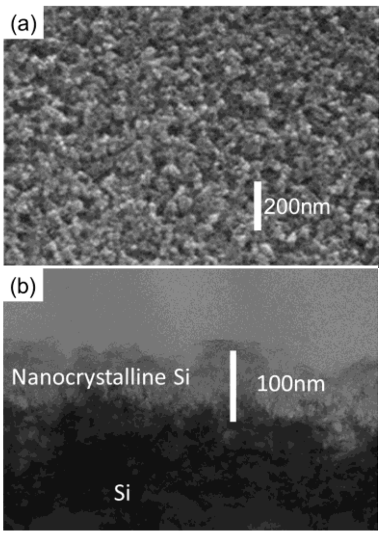

Figure 1. SEM micrograph (a), and cross-sectional TEM micrograph (b) of the poly-Si after the SST method.

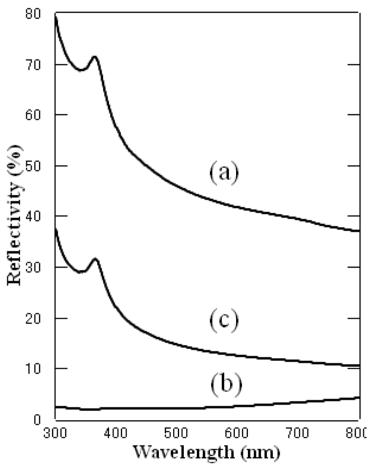

Figure 2. Reflectivity of the poly-Si surface before (a), and after (b) the SSCT method. Reflectivity of a mat-textured Si surface formed on Si(100) surface by isotropic alkaline etching is shown by curve (c).