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Position-specific design of Si nanocone arrays by surface diffusion at the nanostructured surface for maximum photoabsorption

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Abstract:

Recently, solar cells have been attracted as for renewable and alternative energy sources. While the light conversion efficiency of conventional Si solar cells already reached near the theoretical upper limit, it is still necessary for enhancing the solar efficiency to minimize the light reflection at the surface of solar cells. By using the anti-reflection coating (ARC), the light losses induced reflection could be minimize. However, conventional ARC based on dielectric thin films can suppress the light reflection in the specific wavelength range. In order to achieve the antireflection effect with a wide range of bandwidth, the layer with graded refractive index is required. For this reason, cone-shaped Si nanowires arrays could be most suitable ARC due to their gradually changed refractive indices, and many researches are going on to find efficient growth method.

In this study, we introduce a new strategy to control silicon nanowire morphology (cone shape and cylindrical shape) by exploiting surface diffusion at the nanostructured surface. In our approach, by using chemical treatment with a mixture of HF and H_2SO_4 acids, ordinary flat Si substrates were changed to nanoscale-faceted, corrugated surfaces, accompanied by a transition from a hydrophobic to hydrophilic surface. These nanostructured surfaces enhanced the surface diffusion, which eventually stimulated radial growth to change the nanowire morphology from a cylindrical shape to a cone shape with a sharp tip. We have also demonstrated both cone-shaped and cylindrical-shaped Si nanowires could be achieved selectively on the same chip under the same conditions by using site-specific chemical treatment. Furthermore, these shape-controlled Si nanowires demonstrated an outstanding anti-reflection effect over a broad range of wavelengths, as determined by optical measurements and finite-difference time-domain modeling.