Large-area Crystalline Silicon Nanostructured Solar Cells by MACE

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Abstract: Si nanostructures arrays provide a promising approach to enhancing the energy harvesting in the short-wavelength range, for the near zero and small-angle-dependent reflectivity in the short-wavelength region. By employing the well short-wavelength antireflection of the Si nanostructure array, many authors have made relative progresses in the cell performances of the Si nanostructures based solar cells[1-3]. But the energy conversation efficiencies of these Si nanostructures based solar cells are still not satisfied when comparing with those of the traditional solar cells, which is mainly attributed to the large surface recombination loss from the Si nanostructures. Surface passivation such as thermal SiO2[4,5], SiNx:H by plasma enhanced chemical vapor deposition (PECVD) [6,7] and Al2O3 by atomic layer deposition (ALD) [8-10] can effectively suppress the surface recombination by saturating the dangling bonds or forming the fixed charges at and near the surface. Particularly, the stack SiO2/SiNx layers provide an excellent passivation for the Si nanostructures [11,12], which benefits from the well surface passivation of the inner SiO2 as well as the bulk passivation of the outer SiNx:H. The simultaneous surface and bulk passivation guarantee the well electrical performance of the Si nanostructures based solar cells.

Here, we report two novel nanotextures such as nano-microstructures (NM-Strus) and nano-inverted-pyramids, which were prepared on the front surface of solar cells by simple, room-temperature, low-cost and production-compatible metal-assisted chemical etching (MACE). To improve the optical, electrical and device performance, these light-trapping structures are passivated by atomic layer deposition (ALD) Al_2O_3 and plasma enhanced chemical vapor deposition (PECVD) SiO_2/SiN_x thin films, respectively. Our results show a simultaneous achievement of the lowest reflection (1.38%) and the lowest recombination velocity (44.72 cm/s), manifesting a highest energy conversation efficiency of 21.04% for the n-type Si NM-Strus based solar cell. Meanwhile, we fabricate a p-type 20.0%-efficiency Si NM-Strus PERC solar cell with the standard size of solar wafer. Furthermore, we prepare a novel Si inverted-pyramids arrays, showing better optical and electrical performances. These novel Si nanostructured solar cells by MACE will be good candidates of the new generation of high-efficiency solar cells.

Keywords: Metal-assisted chemical etching; Solar cells; Atomic layer deposition; Nanostructures; Spectral responses.

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