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Lateral silicon structures for light-trapping enhancement in solar cells

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Si wires vertically grown by the vapor-liquid-solid (VLS) method have been frequently reported in literature, and has been considered as the long-standing symbolic image of this method. The efforts have been focused on studying the vertical Si wires-based solar cells in the last decades. In this study, the lateral or horizontal growth of Si wires recently reported by our group has been incorporated into Si-based solar cell devices. The reduction of optical losses is one of the important factors in obtaining high-efficiency solar cells. In order to achieve this, the top surface of the solar cells are often texturized or covered with antireflection coating. Lateral Si wires and Si film with various morphologies are on the solar cell devices fabricated on Si(001) substrates by the molecular beam epitaxy (MBE). Enhancement of light trapping in the presence of top epitaxial layer was demonstrated. We analyzed the surface morphology and size distribution of Si wires and alternative morphological features by scanning electron microscopy (SEM). Our results show that the lateral growth of silicon wires has been only initiated around the carbon-contaminated Au catalyst particles covered surface areas. The performance of lateral Si wire-based solar cells has been tested and correlated with topmost Si layer morphology. Efficiency enhancement by 1.5 to 2.5 times was observed for highly corrugated surfaces. Notably, the best efficiencies are achieved for Si overlayer structures (Si wires, ridges and films), where significant area on the surface becomes covered with rough epitaxial Si structures, and the magnitude of the surface roughness exceeds 200-500nm. Different mechanisms contributing to this enhancement will be discussed.

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