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Effects of epitaxial growth on the optimum condition of intrinsic amorphous silicon oxide buffer layers for silicon heterojunction solar cells

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Key words silicon heterojunction solar cells; amorphous silicon oxide; surface passivation; epitaxial growth; spectroscopic ellipsometry

Abstract

Intrinsic amorphous silicon oxide ($a\text{-Si}_{1-x}\text{O}_x\text{:H}$) buffer layers were deposited on both sides of crystalline silicon (c-Si) wafers using plasma-enhanced chemical vapor deposition (PECVD) technique. The input gas flow ratio of carbon dioxide (CO_2) to silane (SiH_4) was varied in a wide range to study the passivation and structural properties of the $a\text{-Si}_{1-x}\text{O}_x\text{:H}$ buffer layers. In this work, when the $a\text{-Si}_{1-x}\text{O}_x\text{:H}$ layer was quite thick (>15 nm), an extremely high effective lifetime of ~ 10 ms was achieved on the n-type float-zone c-Si (~ 3 $\Omega\text{-cm}$, ~ 280 μm) at moderate CO_2/SiH_4 flow ratios, resulting in an exceptionally low surface recombination velocity (< 1.4 cm/s). However, when CO_2/SiH_4 flow ratio was either rather low (< 0.13) or extremely high (> 0.47), the surface passivation quality would deteriorate significantly. In addition, a certain amount of epitaxial phase (epi-Si) was observed in some excellent buffer layers made at the moderate CO_2/SiH_4 ratios. Moreover, it was found that the epi-Si content could be gradually suppressed by slightly increasing the CO_2/SiH_4 ratio without affecting passivation quality. When the $a\text{-Si}_{1-x}\text{O}_x\text{:H}$ buffer layer thickness was kept at only a few nanometers as required by silicon heterojunction (SHJ) solar cells, the PECVD optimum condition (CO_2/SiH_4 ratio) for buffer layers was revealed by applying the $a\text{-Si}_{1-x}\text{O}_x\text{:H}$ buffer layers directly in a practical SHJ solar cell. We found that when the $a\text{-Si}_{1-x}\text{O}_x\text{:H}$

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