Accepted Manuscript

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PII: S0040-6090(17)30223-7
DOI: doi: 10.1016/j.tsf.2017.03.040
Reference: TSF 35888

To appear in: *Thin Solid Films*

Received date: 6 August 2016
Revised date: 11 March 2017
Accepted date: 17 March 2017

Please cite this article as: He Zhang, Kazuyoshi Nakada, Makoto Konagai , Effects of epitaxial growth on the optimum condition of intrinsic amorphous silicon oxide buffer layers for silicon heterojunction solar cells. The address for the corresponding author was captured as affiliation for all authors. Please check if appropriate. Tsf(2016), doi: 10.1016/j.tsf.2017.03.040

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-$Si_{1-x}O_x$: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-$Si_{1-x}O_x$:H buffer layers. In this work, when the a-$Si_{1-x}O_x$: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 Ω-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-$Si_{1-x}O_x$: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-$Si_{1-x}O_x$:H buffer layers directly in a practical SHJ solar cell. We found that when the a-Si_{1-}