Effects of annealing process on CZTS thin-film solar cell

Kee-Jeong Yang[1,2], and Jun-Hyoung Sim[2]
[1]Green Energy Research Division, DGIST, Daegu, 711-873, Korea
Tel.:82-53-785-3750, E-mail: kjyang@dgist.ac.kr
[2]Advanced Convergence Research Center, DGIST, Daegu, 711-873, Korea

Cu_2ZnSnS_4 (CZTS)-based solar cells represent a significant improvement because of a useful band-gap energy and a high absorption coefficient. In this study, we investigated annealing effects of device on CZTS solar cell characteristics.

We verified that the solar cell characteristics improve in direct proportion to the Na concentration in a Mo layer before CZTS deposition. The Na concentration in the Mo layer increased in proportion to the increase in Mo-layer annealing temperature. SIMS composition profiles show that Na is accumulated near the Mo-layer surface. The Na accumulated on the surface is rapidly diffused into the absorber layer at the initial stage of CZTS deposition. As the Mo-layer annealing temperature increased, the voltage shortfall decreased. This indicates that the concentration of recombination centers in the absorber layer was reduced. In addition, the grain boundaries in an absorber layer with a higher Na concentration are passivated more efficiently. A decrease in recombination-induced losses is observed in the samples that exhibit a more efficient passivation of GBs that act as a current flow channel. Such a correlation indicates that a CZTS absorber formed on a Mo layer with a high initial Na concentration contains fewer bulk defects, which correspond to a decrease in V_{OC} losses and improvement of solar cell characteristics.

Also we verified that the solar cell characteristics decline in direct proportion to the Na concentration in a CdS buffer layer. SLG/Mo/CZTS/CdS/transparent conducting oxide-structured sample was annealed to control the Na concentration in a buffer layer. After CZTS absorber layer sulfurization process, Na is accumulated near the absorber layer surface. When a buffer layer was deposited on the absorber layer, Na near the absorber layer surface is diffused into a buffer layer. Transmission energy dispersive spectrometer compositional profiles show that the Na concentration in a buffer layer decreased after annealing process. Na in a buffer layer acts as an ionized impurity and scatters the minority carrier; thus, the minority carrier path is deflected and the minority carrier mobility decreases. As the minority carrier mobility decreases, device series resistance increases. So Na concentration in a buffer layer must be reduced.

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References

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