UNSW: Development of Beyond 20% Efficiency Kesterite (CZTSSe) Solar Cells: win the PV race with sustainable low-cost, low-toxic and stable materials

LESSONS LEARNT REPORT 2

Project Details

Recipient Name and website	The University of New South Wales
Primary Contact Name	A/Prof. Xiaojing Hao
Contact Email	Xj.hao@unsw.edu.au
Reporting Period	Milestone 2

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Lessons Learnt Report: Interface passivation via epitaxial grown ZnSe nano layer

Project Name: Development of Beyond 20% Efficiency Kesterite (CZTSSe) Solar Cells: win the PV race with sustainable low-cost, low-toxic and stable materials

Knowledge Category:	Technical
Knowledge Type:	Technology
Technology Type:	Solar PV
State/Territory:	NSW

Key learning

The epitaxial grown ZnSe nano layer has very small lattice mismatch with CZTSe (1.04%), which enables a strain free interface. The relatively high conduction band and low valance band of ZnSe thus renders perfect surface passivation effect. As long as the thickness of this ZnSe layer is limited to several nanometres, the electron transport is not limited due to thermal-assisted tunnelling process.

Implications for future projects

Using ZnSe as epitaxial passivation layer for CZTSSe solar cells is a promising strategy to improve the performance of kesterite solar cells. This will be an important base for high efficiency CZTSSe solar cells and could be applicable to other materials with similar lattice structure.

Background

Objectives or project requirements

The non-radiative recombination at heterojunction interface is the main loss mechanism in most cases including CZTSSe solar cells. Therefore, interface passivation is critically important for CZTSSe solar cells.

Process undertaken

The soft-selenization introduced between alloying treatment and high temperature selenization leads to a Zn-rich local composition at the top of absorber, which enables an epitaxial ZnSe nano layer on the surface of CZTSSe film.

Lessons Learnt Report: large grain spanned monolayer CZTSSe absorber enabled by modified mass transfer

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Key learning

The non-radiative recombination within the quasi-neutral region could be suppressed by employing large grain spanned monolayer CZTSSe absorber, which could be fabricated with low alloying temperature and slow ramp rate that enables sufficient mass transfer before large grains forms at high temperature.

Implications for future projects

The cross-sectional morphology of light absorber is important for carrier transport of solar cell especially when the grain boundaries are not passivated. The control of favourable large grain spanned monolayer cross-section morphology is an important foundation for high performance devices, not only CZTSSe, but also other emerging solar cells.

Background

Objectives or project requirements

The voids, small grains, and secondary phases at the bottom of the CZTSSe absorber have been identified as one of the main recombination regions that is responsible for the large Jsc loss at long wavelength region and the inferior fill factor. To address this issue, large grain spanned monolayer absorber is required.

Process undertaken

By controlling the alloying temperature, modifying the ramp profile and the Se supply during selenization, the mass transfer during the growth of CZTSSe has been greatly improved, thus enabling large grain spanned monolayer CZTSSe absorber and much better carrier collection efficiency at long wavelength region.

Lessons Learnt Report: combining back surface electron reflector and back surface field with CZGSSe layer

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State/Territory:	NSW

Key learning

The non-radiative recombination at the back surface of CZTSSe absorber can be suppressed by introducing a Ge based CZGSSe layer which has similar valance band edge and much higher conduction band edge comparing to CZTSSe. The CZGSSe layer can act as an electron reflector at the bottom whist enables proper hole transfer to the back contact, thus improves the overall performance of CZGSSe solar cells simultaneously.

Implications for future projects

The concept of electron or hole reflector at front or back interface can be an effective method for interface passivation for other electronic devices.

Background

Objectives or project requirements

The non-radiative recombination at the back surface is known to be responsible for the loss at long wavelength region. This requires effective way to passivate the back surface. However, due to the substrate architecture, the passivation of back surface of CZTSSe is very challenging.

Process undertaken

Nano crystalline CZGS layer has been applied at the back of CZTS absorber. This strategy has shown significant improvement on the fill factor of CZTS solar cells. Investigation of nano crystalline CZGSSe layer for CZTSSe absorber is undertaking.