BAPVC Annual Project Report

Project Title: Si/II-VI Double-heterostructure solar cells

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Summary:

The idea of this project is to use conductive, monocrystalline and wide bandgap II-VI semiconductor layers to replace TCO/doped a-Si:H/undoped a-Si:H for Si based heterostructure solar cells. The group has demonstrated enhanced lifetimes of p-type Si wafers using p-type ZnTe layer to passivate the surface.

Key Accomplishments:

A new MOCVD reactor has been set up at RPI, as shown in Fig. 1 (a), to grow II-VI semiconductors on Si substrates. Several p-type ZnTe films have been grown and characterized for doping concentration and resistivity. Highly doped ZnTe film with minimum resistivity of 0.3 ohm-cm has been grown on semi-insulating GaAs substrates. The use of semi-insulating GaAs substrates is for the electrical Hall measurements. An atomic hydrogen source has been installed on the MBE system at ASU as shown in Fig. 1(b). It is used to clean Si substrate surface before the MBE growth of II-VI layers.

(a) (b)

Fig. 1 (a) An installed MOCVD reactor at RPI for growing II-VI semiconductor films on Si; and (b) An atomic hydrogen source installed on the MBE system at ASU for cleaning the Si wafers.

A non-contact lifetime measurement system using a microwave reflectance technique has been set up at RPI to measure the carry lifetime. The samples studied consist of a thin p-type ZnTe layer deposited on the front surface of the p-type Si wafers by MOCVD. Microwave reflectivity decay is measured prior and after the deposition of the p-type ZnTe on silicon. As shown by the red and black curves in Fig. 2, significant improvement in decay time, which is a function of bulk lifetime and surface recombination velocity, is observed in the samples with the p-type ZnTe layer deposited on the front surface, implying good passivation of Si surface by ZnTe.

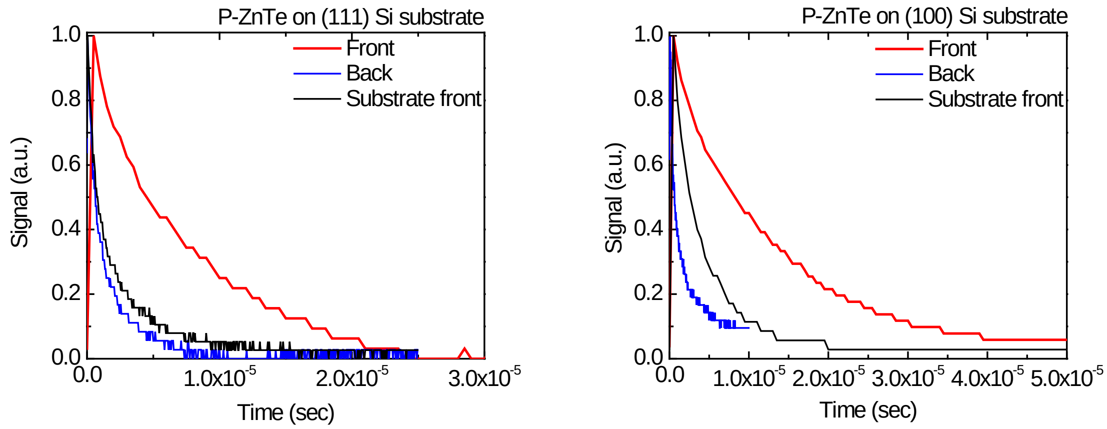

Fig. 2 Microwave reflectance decay of p-type silicon prior and after the deposition of the p-type ZnTe layer. A comparison between the red and black curves indicates a longer carrier lifetime due to surface passivation.

This program has also inspired ASU team to invent several new ideas for low-cost tandem cells based on Si. It has filed an invention disclosure and initiated some collaboration in industrial partners like First Solar and JA Solar.

Invention disclosure:

1. Yong-Hang Zhang, *Low-cost and high-efficiency polycrystalline II-VI thin-film and Si tandem solar cells*, filed 12/31/2013.

Related Publications

1. M. J. DiNezza, X.-H. Zhao, S. Liu, Y.-H. Zhang, *Growth, steady-state, and time-resolved photoluminescence study of CdTe/MgCdTe double heterostructures on InSb substrates using molecular beam epitaxy*, Appl. Phys. Lett. **103**, 193901 (2013).
2. S. Liu, J. Becker, S. Farrell, W. Yang, Y.-H. Zhang, *SiO_2/ZnSe Anti-reflection Coating for Solar Cells*, Proceedings of the 39th IEEE PVSC, 2013.

Future Work:

Both ZnSe and ZnTe layers will be deposited on Si using MOCVD and MBE. The II-VI thin films will be characterized using XRD, PL and TRPL. Carrier transport across the Si/II-VI interface will be investigated. Preliminary solar cell structures will be fabricated. Surface passivation will be correlated with the solar cell device performance.