AlGaAs Solar Cells Grown by Liquid Phase Epitaxy for Dual Junction Solar Cells Based on c-Si Bottom Sub-cell

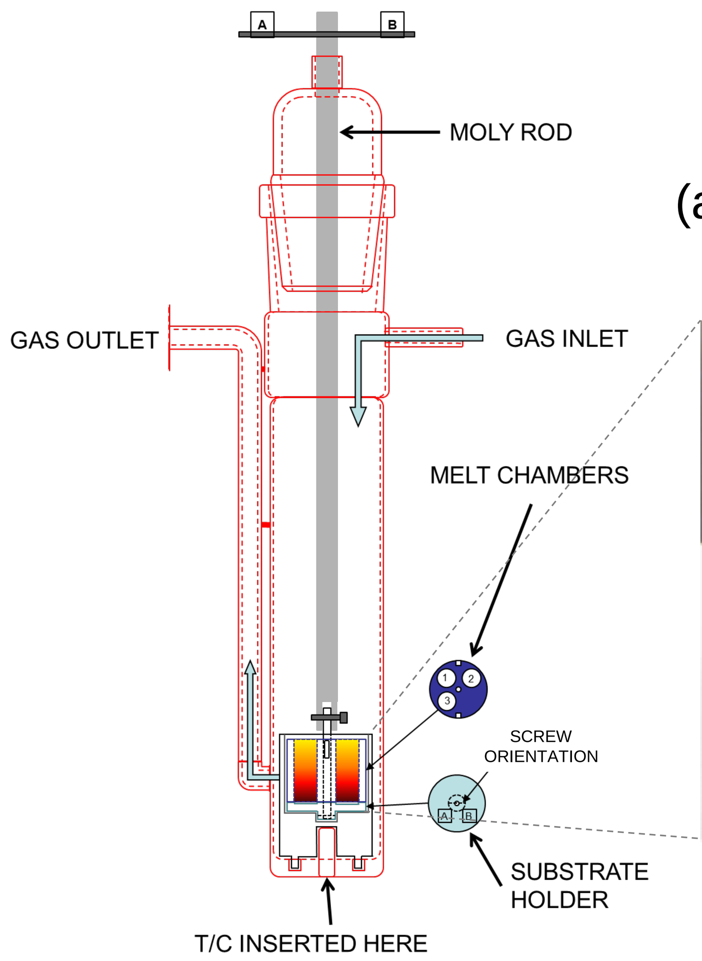
Xin Zhao, Kyle H. Montgomery, and Jerry M. Woodall
Department of Electrical and Computer Engineering, University of California, Davis, CA, 95616, USA

Introduction

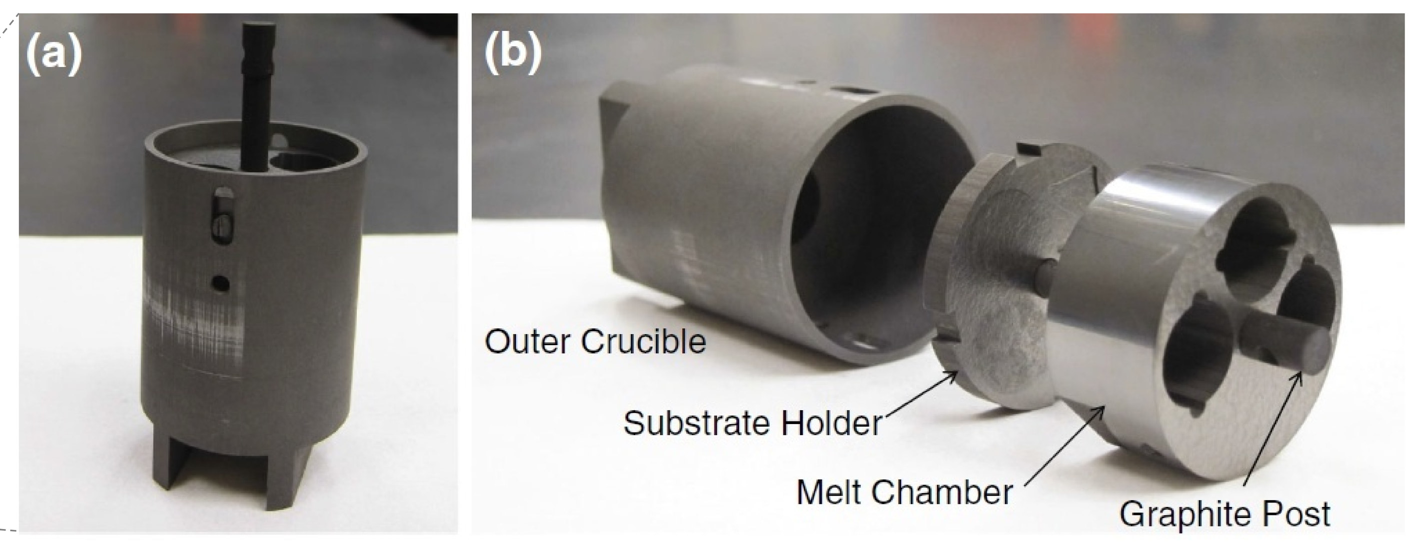
Theoretically, for a dual junction device, a top sub-cell bandgap of ~1.75eV enables a near-optimal power conversion efficiency of more than 38% under AM1.5G condition, assuming an optimized c-Si bottom sub-cell [1]. With a direct bandgap covering 1.42 – 2 eV, AlGaAs is a candidate for the top sub-cell material. AlGaAs can be grown lattice-matched on a GaAs substrate first, and then be bonded to a Si bottom sub-cell with the native substrate subsequently removed [2]. Direct liquid phase epitaxial (LPE) growth of AlGaAs on GaP/Si superstrates is also feasible because efficient electroluminescence has been observed from LPE-grown AlGaAs on GaP [3]. The growth of Al-rich AlGaAs by alternative growth techniques such as molecular beam epitaxy (MBE) or metalorganic chemical vapor deposition (MOCVD), however, are typically plagued by oxygen incorporation. Since LPE is known for its capability of growing high-purity AlGaAs due to its liquid-solid growth interface, it was used for our study of AlGaAs epilayers and solar cells.

This poster will cover the behavior of various dopants (Sn and Te as n-type dopants, and Ge and Zn as p-type dopants) in $Al_xGa_{1-x}As$ (x ~ 0.23). Also included are dark IV, light IV and EQE results of AlGaAs solar cells.

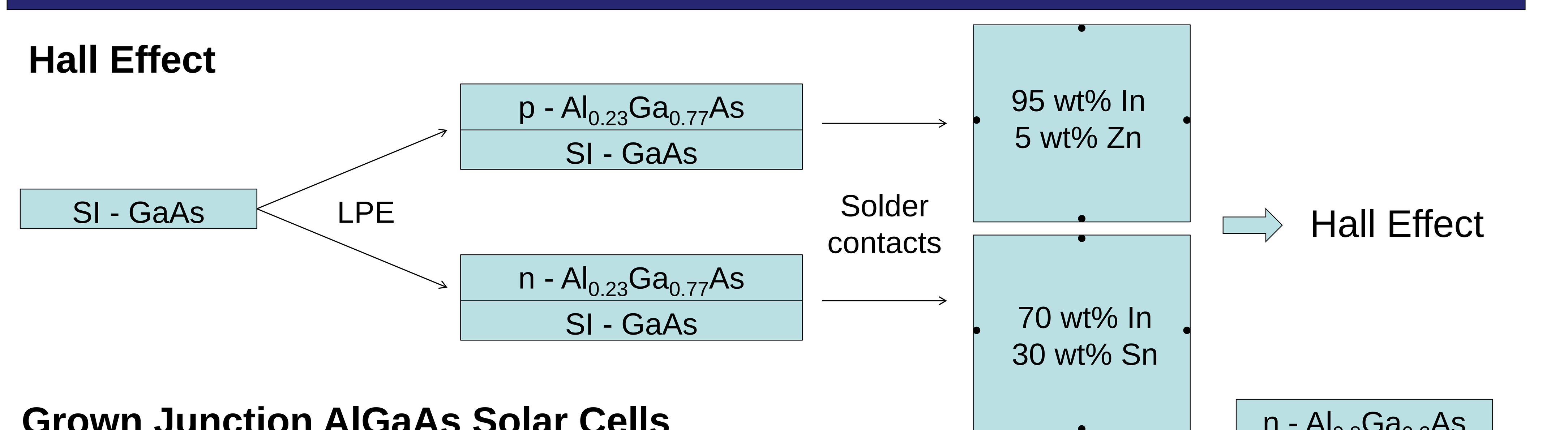
LPE Apparatus

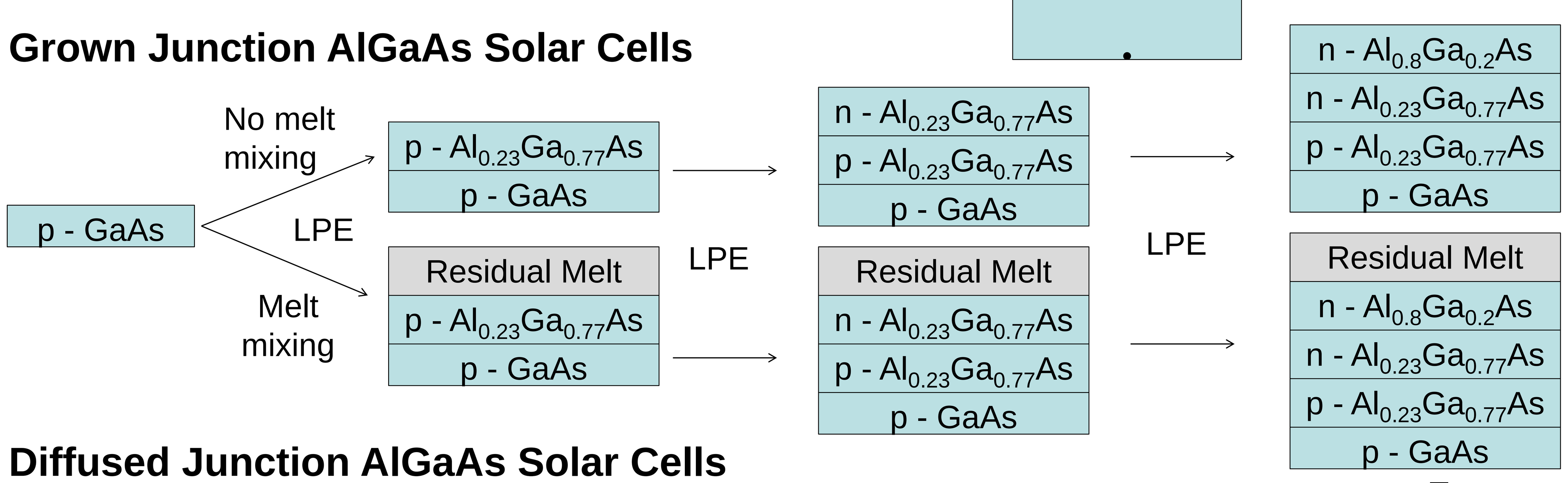


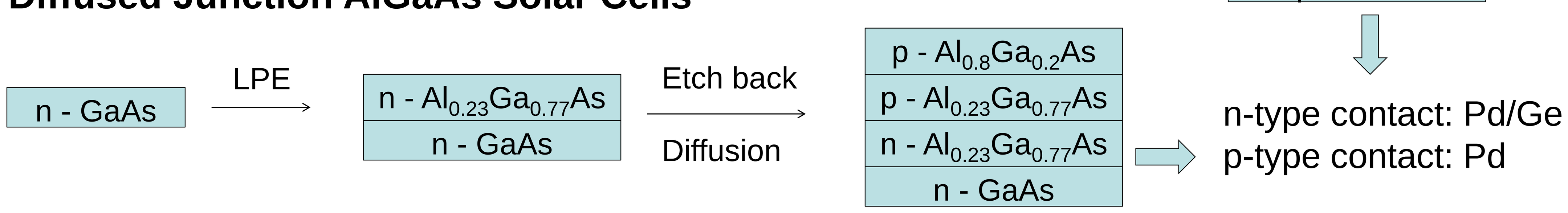
(a) Assembled view and (b) exploded view of graphite apparatus



Methods

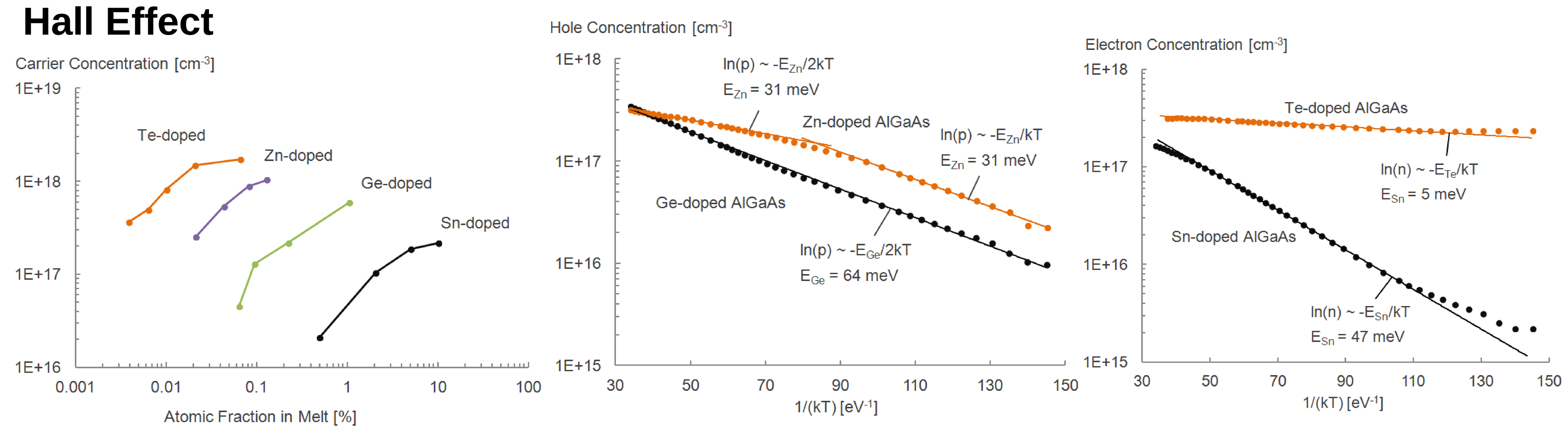




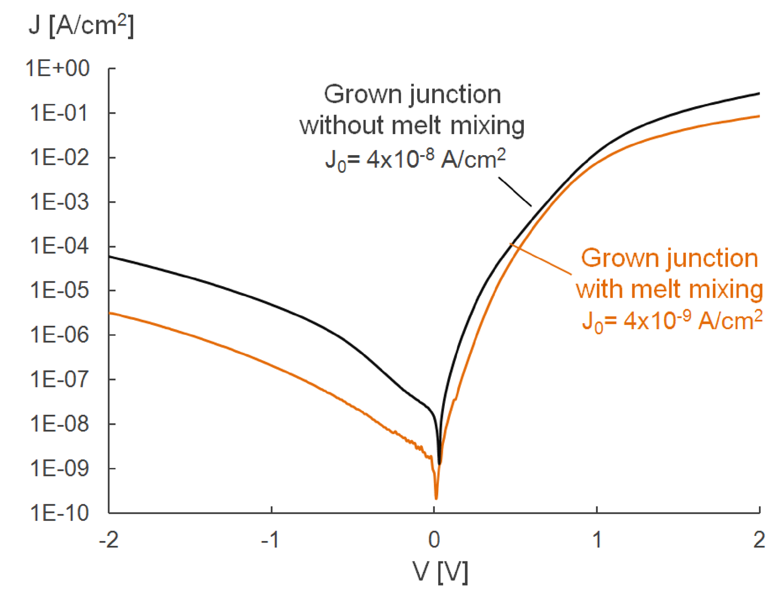


Results

Hall Effect

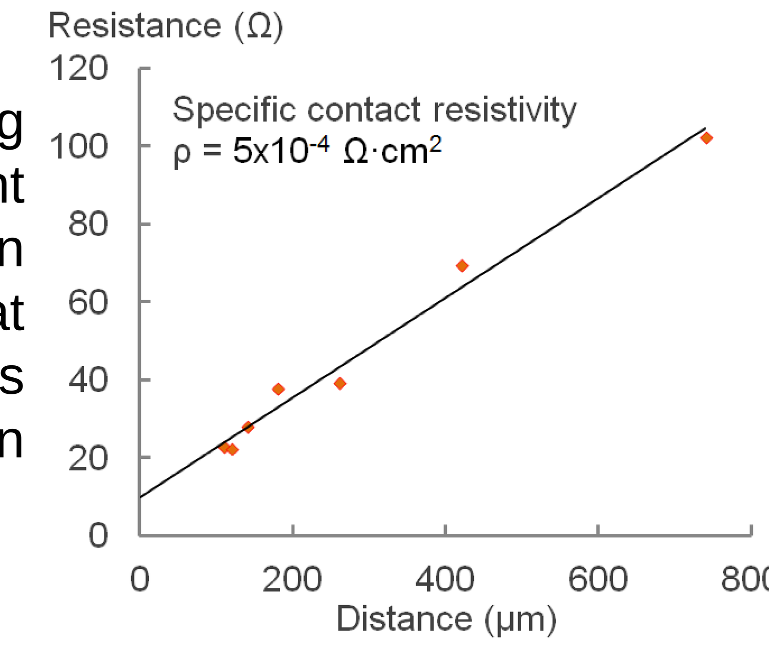


Grown Junction AlGaAs Solar Cells



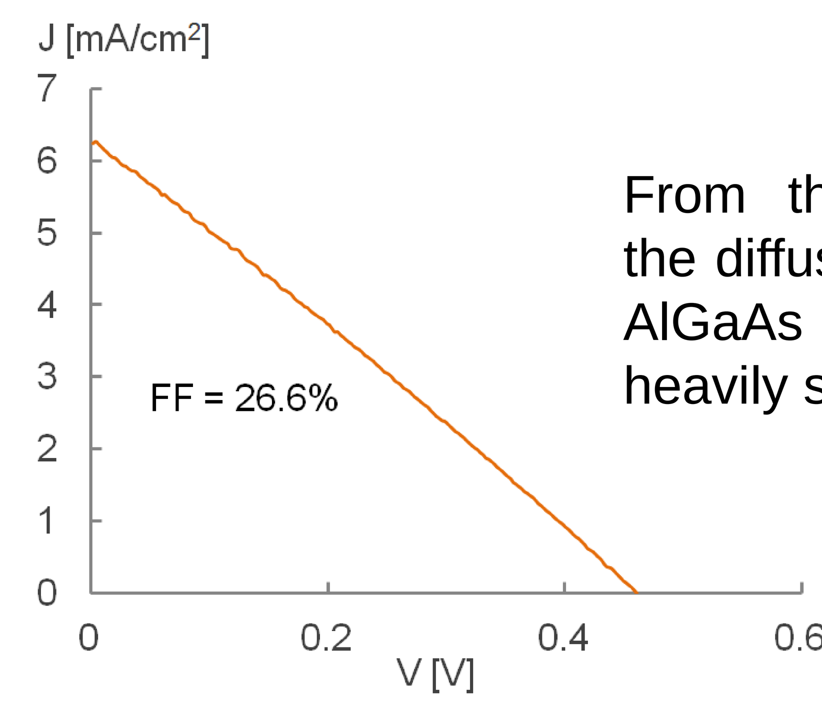
Dark IV characteristics of grown junction devices

Melt mixing helps reducing the dark saturation current density in grown junction devices due to the fact that the sample surface is always protected by a thin melt.



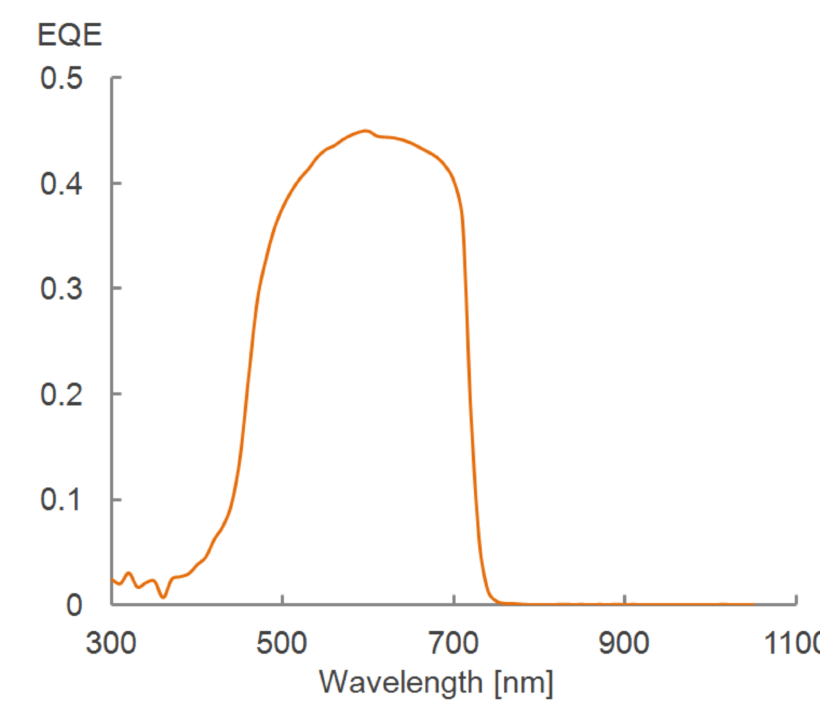
Contact resistivity of Pd/Ge on n - $Al_{0.23}Ga_{0.77}As$ (n ~ $10^{18}cm^{-3}$)

Diffused Junction AlGaAs Solar Cells



Light IV characteristics of a diffused junction device

From the light IV, the diffused junction AlGaAs solar cell is heavily shunted.



EQE of the device with light IV characteristics on left

Conclusion

We have performed Hall effect studies on ~1.75eV AlGaAs, and, based on the results, fabricated preliminary AlGaAs solar cells for tandem solar cell applications. The diffused junction cells generally perform better than grown junction cells, and therefore are the focus of our current study. In order to improve the efficiency of diffused junction AlGaAs solar cells, a detailed study of the cause of shunting in the device is required and is under our current investigation.

References

[1] S. R. Kurtz, P. Faine, and J. M. Olson, "Modeling of two-junction, series-connected tandem solar cells using top-cell thickness as an adjustable parameter," *Journal of Applied Physics,* vol. 68, no. 4, pp. 1890-1895, 1990.

[2] K. Tanabe, K. Watanabe, and Y. Arakawa, "III-V/Si hybrid photonic devices by direct fusion bonding," *Scientific Reports*, vol. 2, pp.1-6, 2012.

[3] J. M. Woodall, R. M. Potemski, S. E. Blum, and R. Lynch, “$Ga_{1-x}Al_xAs$ LED Structures Grown on GaP Substrates,” *Applied Physics Letters,* vol. 20, pp. 375, 1972.

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