Materials Science & Engineering Doctoral Defense

Interaction of Charge Carriers with Defects at Interfaces and Grain Boundaries in Compound Semiconductors

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Abstract

Realization of efficient photovoltaic cell with high bandgap in an economically viable manner is one of the technological advances that could accelerate the development of human civilization. A material needs to be engineered that has high bandgap, has relatively inactive defects, is thermodynamically stable in ambient conditions and is economically viable for mass manufacturing.This work focuses on a material system made of gallium, indium, and phosphorus – hereafter referred to as GaInP. GaInP based photovoltaic cells, in single crystalline form, have demonstrated excellent power conversion efficiencies. Growth of single-crystal GaInP in prohibitively expensive. While growth of polycrystalline GaInP is expected to lower its cost of production, polycrystalline GaInP is expected to have a lot of defects, about which not a lot is known at this time. This work presents the first study of synthesis, and structural and optoelectronic characterization of polycrystalline GaInP thin films.In addition, this work models the best performance of solar cells achievable with a particular grain size and the recombination velocities needed to achieve it. Effect of defect characteristics at the surface and layer properties like doping and thickness that affect the recombination velocities are also modelled.Recombination velocities at the free surface of single crystalline GaInP and after deposition of various high-k dielectric layers on GaInP is experimentally quantified using time resolved photoluminescence decay measurements. In addition, bulk lifetime, and surface recombination velocity of effectively passivated single crystal AlInP-GaInP based double heterostructures is also measured. All these studies enabled the development of a novel passivation method for polycrystalline thin films. A novel passivation method, named – aluminum assisted post deposition treatment, is introduced that has demonstrated improvement in the minority carrier lifetime of polycrystalline GaInP to nearly 40 ns at 80K. During the development of the passivation process, aluminum diffusivity in GaInP is also quantified using TEM-EDS line scans. Introduction, development, and demonstration of this novel passivation mechanism in polycrystalline GaInP could initiate the development of a new family of passivation treatments to improve the optoelectronic response of many other polycrystalline compound semiconductors.

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Zoom Link: https://asu.zoom.us/j/86749794453?pwd=RkJ6S2R1ci8xamQ3Vnd3MTJXT28yZz09