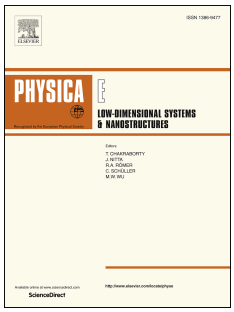
Accepted Manuscript



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PII: S1386-9477(18)30546-0

DOI: 10.1016/j.physe.2018.07.011

Reference: PHYSE 13214

To appear in: *Physica E: Low-dimensional Systems and Nanostructures*

Received Date: 12 April 2018

Revised Date: 18 June 2018

Accepted Date: 12 July 2018

Please cite this article as: S. Khosroabadi, A. Kazemi, High efficiency gallium phosphide solar cells using TC-doped absorber layer, *Physica E: Low-dimensional Systems and Nanostructures* (2018), doi: 10.1016/j.physe.2018.07.011.

High efficiency Gallium Phosphide solar cells using TC-doped absorber layer

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Abstract

In this work, we have investigated the structural and magnetic properties of GaP-based diluted magnetic semiconductors (DMSs). Based on first-principle density functional theory (DFT) calculations and using a full potential linearized augmented plane wave (FP-LAPW) method in generalized gradient approximation (GGA), some significant structural and magnetic properties of Transition Compounds-doped Gallium Phosphide ($Ga_{1-X}TC_XP$: TC=V, Mn, Fe, Co, Ni & Cu) as DMS are investigated. Then, a conventional gallium phosphide photovoltaic junction was simulated with a GaP absorber layer as reference cell. Last, a high efficiency gallium phosphide photovoltaic junction was proposed with a $Ga_{1-X}TC_XP$ absorber layer. Simulation results showed that by using $Ga_{1-X}TC_XP$ compound, the short-circuit current density (J_{SC}) and the conversion efficiency of proposed solar cell increase impressively. Under global AM 1.5 conditions, the proposed cell structure has an open-circuit voltage (V_{OC}) of 1.01V, J_{SC} of 9.05 mA/cm^2 and a fill factor (FF) of 88%; all in all lead to total area conversion efficiency (η) improved to 8.06% which increased about 5.93% compared with a reference cell.

Keywords: GaP – transition component – efficiency – solar cell – output power

1. Introduction

Semimagnetic semiconductors, mostly known as Diluted magnetic semiconductors (DMSs), have achieved tremendous attentions due to their important properties [1, 2]. They are applicable in fast emerging field of spintronics [1, 3]. Some of their physical properties such as energy gap, lattice constant and effective mass can be tuned by varying composition. Moreover, magnetic ions could be substituted in lattice structure of DMSs i.e. ternary semiconductor compounds. Such as energy band, the impurity level parameters of the semiconductor e.g. the electronic g-factors, are affected by spin-spin exchange interaction. This interaction is between the band electrons and the localized magnetic moments due to the presence of magnetic ions in the DMS lattice, which are all resulting in new physical properties particularly when quantizing magnetic fields are present. DMSs are created By doping the magnetic ions of the type TC (≡ Mn, Fe, Co, Cu, and the others) in the wide band-gap metal oxides such as TiO_2 and/or ZnO and semiconductors such as GaN, GaAs, ZnTc [4, 5] and GaP.

Having 2.26 eV indirect band-gap at room temperature, GaP is a well candidate to be used in various fields of applications when doped with transition component [6–10]. Mn-doped GaP with following formula ($Ga_{1-x}Mn_xP$; x=25%) shows ferromagnetism at Curie temperature T_C = 110 K as reported by Ohno et al. [11]. That also be reported by Reed et al. at different temperatures and in other applications [12]. Moreover, much theoretical efforts have been performed using first-principle calculations in the framework of DFT i.e. Density Functional Theory to confirm above mentioned properties in additional to magnetic, electronic and structural properties [13]. Fig. 1 shows a schematic representation for crystal structure of TC-doped GaP where TC atom is a transition component.