Optimization of MBE grown GaInP for tandem cell use

Amadéo Michaud[1,3] , Ahmed Ben Slimane[2] Thomas Bidaud[3],Ludovic Largeau[3],Jara Fernandez Martin[1], Stéphane Collin[2,3], Jean-Christophe Harmand[3]

(1) Total, New Energies, Ecole Polytechnique-IPVF, 30 route départementale, 91128, Palaiseau, France

(2) Institut photovoltaïque d'Ile de France –IPVF 30 route départementale, 91128, Palaiseau, France

(3) Centre de Nanosciences et de Nanotechnologies-C2N, route de Nozay, 91460, Marcoussis, France

Gallium Indium Phosphide (GaInP) is widely used as a top junction in multi-junction solar cells, it also allows to assemble some of the best III-V/Si tandem solar cells [1]. While designing solar cells, most of the attention goes to the cell's structure optimization, but growth aspect cannot be neglected in the case of GaInP.

In certain growth conditions GaInP tends to arrange in Gallium rich and Indium rich plans. This superlattice like behavior, called ordering impacts the alloy properties. GaInP grown lattice matched to Gallium Arsenide (GaAs) with bandgap from 1.83 eV to 2 eV were reported [2]. Carrier lifetimes variation and diffusion anisotropy [3] are two other consequences. Therefore substantial care on the growth environment is required to provide a good photovoltaic material.

In this work we highlight how the growth conditions impact the quality of our MBE grown GaInP by means of photoluminescence and time-resolved cathodoluminescence. A bandgap variation of 96 meV was obtained while varying growth temperature and phosphorus pressure. Scanning Transmission electron microscopy (STEM) confirmed the local composition variation for certain conditions. Then we emphasize that optimization of the epitaxy chamber is still needed in order to catch up with state of art cells. Thus our cells suffer from low lifetimes and mobilities in the p-doped base layer.

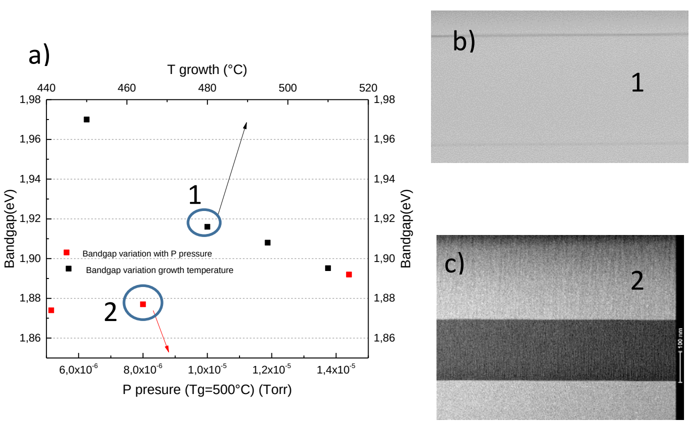

Figure 1: a) GaInP bandgap variation with growth temperature and phosphorus pressure, STEM images showing b) homogenous material in condition 1 c) partially ordered material in condition 2

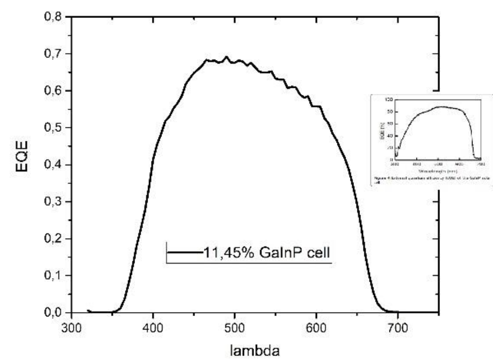

Figure 2: EQE of our best GaInP cell, insert EQE of a 16.4% efficient GaInP cell [4] emphazing the progresses needed in the base

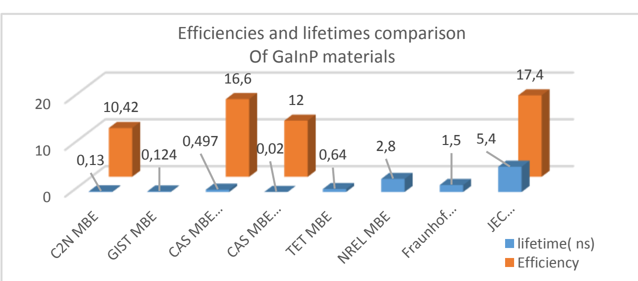

Figure 3: Comparison of lifetimes and PV conversion efficiencies of GaInP from different labs and epitaxy techniques

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[2] S.F. Yoon*, K.W. Mah, H.Q. Zheng "Effect of V/III ratio and temperature dependence of carrier concentration in partially ordered and disordered Ga0.52In0.48P grown on GaAs substrates" - Journal of Crystal Growth 208 (2000)

[3] N.M Haegel, T.J. Mills, M Talmadge "Direct imaging of anisotropic minority-carrier diffusion in ordered GaInP"- J. Appl. Phys. 105,023711(2009)

[4] Lu, S., Ji, L., He, W., Dai, P., Yang, H., Arimochi, M., Ikeda, M. (2011). High-efficiency GaAs and GaInP solar cells grown by all solid-state molecular-beam-epitaxy. Nanoscale Research Letter