**Toward a III-V/Si tandem solar cell: characterization and modeling**


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**ABSTRACT**

III-V/Si tandem solar cells are promising candidates for a more efficient solar energy conversion (theoretical max. ~37% [1]) at a relatively low cost thanks to the well-established Si technology. GaAsPN alloys can be lattice matched to Si and exhibit a direct 1.7 eV [1] band gap making it the ideal material for the top cell. However, technological issues remain, such as the III-V growth. Here, we study a very first set of GaAsPN diodes and structural defects (APD) in GaP from a modeling point of view. This preliminary study aims at the understanding of the behaviour of the III-V layer to be monolithically integrated to Si.

**III-N-V diodes characterisation**

The studied diodes are:

- GaP (n⁻) 100 nm (N⁺=2E18)
- GaP (n⁻) 30nm (N⁺=1E18)
- GaP (p⁺) 30nm (N⁻=2E18)
- GaAsPN (n⁻) 100nm (N⁺=1E18)
- Substrate GaP (n⁻) 300μm (N⁺=1E18)

The absorption onset is red-shifted with the presence of Nitride.

The refection of the diode is very high and explains the poor EQE measured. An AR layer is needed.

The efficiency is low, mainly due to the weak Jsc, but the Voc is very encouraging. The absorber layer has to be thinner to generate a higher Jsc. We can furthermore notice that we face a collection issue with the nitrided diodes and good resistance values.

**GaP (110) Anti-Phase Domain ab initio studies**

Growth of GaP on Si (001) substrates is known to create Anti-Phase Domains (APDs) in the III-V layer. Anti-Phase Boundaries (APBs) nucleate on Si surface monosteps.

Study of (110) APDs requires a 4 atoms tetragonal unit cell.

**Structure optimization of a p-i-n Gap/GaAsPN/GaP**

We have simulated with SCAPS the structure characterized above.

Most important parameters:

- Doping level of n-GaP
- Absorber thickness

N⁺ = 2E18
N⁻ = 1E19
N⁺ = 1E18
N⁻ = 1E19

- The absorber thickness determines the device efficiency only if the p-GaP layer is doped enough.

**References**


**Conclusion**

We have been able to characterise preliminary GaAsPN diodes. Despite an encouraging V oc, the absorber has to be thicker and the n-GaP doping higher for an optimized structure. Examination of APDs in GaP revealed the presence of potential recombination centers. Further modeling studies including the Si substrate are necessary to collect more knowledge on the III-V/Si system.