Pseudomorphic and metamorphic (Al)GaAsSb/(Al)InGaAs tunnel junctions for GaAs based Multi-Junction Solar Cells.

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Aim and approach - Tunnel Junctions (TJs) are key devices for monolithic Multi-Junction Solar Cells (MJSCs), in which they ensure the series interconnection between the subcells. For GaAs based MJSCs, very low resistive (with peak tunneling current density J_{peak} up to 10 kA/cm²) AlGaAs:C/GaInP:Te or AlGaAs:C/GaAs:Te have been recently developed by MOVPE using Te instead of Si as N-dopant making it possible to get the heavily doping levels needed for tunneling optimization [1]. In this work, we investigate an alternative to this approach. The tunneling probability is increased through the engineering of band-offset thanks to the use of a type II (Al)GaAsSb/(Al)InGaAs staggered heterojunction. Such TJs are suitable for both lattice-matched and metamorphic MJSCs.

Scientific innovation and relevance – MBE was used to grow pseudomorphic and metamorphic (Al)GaAsSb/(Al)InGaAs TJs (5% to 10 % In and Sb contents) on GaAs substrate, where Aluminium enables to limit light absorption in the TJ. We have experimentally and theoretically investigated the role of the layer thicknesses on the tunneling mechanisms to propose TJ heterostructure designs suitable for lattice-matched MJSCs and metamorphic MJSCs.

Preliminary results and conclusions- For relatively thin [10 to 30 nm] type II TJs, the incorporation of Sb/In in the GaAs TJ is actually degrading the electrical performances, with J_{peak} decreasing from 180 A/cm² for simple GaAs TJ to 70 A/cm² for $GaAs_{0.95}Sb_{0.05}/In_{0.05}Ga_{0.95}As$ TJs. On the other hand, thicker 100 nm (Al)GaASb/(Al)InGaAs TJs present the expected tunneling current density increase with J_{peak} close to 1000 A/cm². It worths to note that such thick TJs lead to strain/relaxation issues that could be detrimental for lattice-matched MJSCs but beneficial for metamorphic MJSCs. The origin of this difference in behavior is under investigation both using a semi-classical model [2] and a Non Equilibrium Green's Function based quantum model [3]. First simulations suggest that it originates from a balance between quantum confinement and type II-related tunneling probability enhancement.

Based on these results, we are developing GaAs/InGaAs/GaAsSb/GaAs TJs suitable for lattice-matched MJSCs with preliminary measurements showing a thousand-fold increase of the peak tunneling current. Complementary, we are studying the relaxation mechanisms of (Al)Ga(In)As(Sb) alloys using in-situ MBE stress measurements in order to optimize the growth of metamorphic (Al)GaAsSb/(Al)InGaAs TJs.

REFERENCES

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