InGaN-based photovoltaic cells

Laboratory: UMI GT CNRS 2958 & LPN UPR 20

Background : The current world record in photovoltaic efficiency is 43.5%, for a GaInP–GaInAs–Ge triple-junction tandem solar cell in a concentrator system. However, this structure is approaching the theoretic limit defined by the band gap of its constituents, and new materials are required to exceed it. InGaN is an ideal candidate for this role: it is a full spectrum material, with a high absorption coefficient, and high thermal, mechanical and chemical resistance. Over the past few years, several prototype InGaN solar cells have been demonstrated, attempting to make use of these advantages. However, experimental InGaN solar cells have yet to take advantage of the full capabilities of InGaN alloys, as several challenges still limit the performance of these devices. The ability to systematically grow single phase, thick, epitaxial InGaN layers figures prominently among these challenges. UMI GT-CNRS and LPN propose the use of a new approach, which has shown a drastic improvement of the material quality, for the growth of thick InGaN epilayers with high indium content.

Research topic : We would like to hire a post doc, co-advised by both LPN (expertise in structural characterization and technological development) and UMI GT CNRS (expertise in MOVPE growth), to further develop this approach, the main objective being the demonstration of efficient InGaN-based solar cells with indium contents larger than 30%. One should note that American, Korean, and Chinese groups have recently started working in this field, and that, to date, UMI GT CNRS is the only group in France to investigate this research field. Recent results using the semi-bulk approach for the MOVPE growth of InGaN have yielded high quality 120 nm thick InGaN layers with an In content of 15%, both values well beyond the epilayers used in the state of the art. Beyond the achievement of high quality InGaN layers, several other challenges need to be addressed to demonstrate P(GaN)/I(InGaN)/N(GaN) junction solar cells: the growth of high quality p-doped GaN cap layers, as well as the deposition of ohmic contacts to p-type (In)GaN with a specific contact of the order of 10^{-4} Ωcm^2. For this, both laser annealing to more efficiently activate Mg ions in the p-GaN layer from one part, and, from the other part, possible use of GaN/InGaN/GaN tunnel junction to replace existing resistive p-type contact, will be investigated. Another possibility also, is to replace the p-GaN layer by a p-InGaN layer, which has higher hole concentrations than p-GaN since the acceptor activation energy decreases with decreasing bad gap energy.

Candidate profile: The successful candidate will be a resourceful, hands-on, problem solver with the capacity to quickly grasp and resolve a wide range of technical problems while managing one or more development efforts. The person should thrive in a high-pressure, deadline-oriented atmosphere. The person should work with a team of scientists, engineers and technicians to develop, improve and integrate new epitaxial growth processes for III-V, nitride-based PV cells. The person should take ownership of MOCVD reactors and processes including scheduling, data analysis, layer characterization, directing equipment maintenance, and experimental design. The minimum requirements are: PhD in Electrical Engineering, Materials Science, Physics and relevant work experience in III-V epitaxial layer growth.

Starting date : July 2013 (1 year duration)

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