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MOVPE of GaAsP/GaAs heterostructures for fabrication of 1.7 eV cell junctions in 4-terminal tandem III-V/Si solar cells

Multi-junction (tandem) solar cells in the form of monolithically stacked III-V cells, each absorbing a different interval of the solar spectrum allow to reach external quantum efficiencies well beyond the Schockley-Qeisser limit for single-junction solar cells [1]. Tandem solar cells based on a Silicon bottom junction are very attractive due to the relative low cost of Silicon substrates; a dual-junction cell with a 1.7 eV top junction based on III-V semiconductors (e.g. GaAsP) and a Silicon (1.12 eV) bottom cell has a theoretical efficiency of ~38%. However, serious structural constrains limit the monolithic growth of III-V compounds onto Si and performances of as-fabricated tandem solar cells remains far from theoretical figures. Four-terminal tandem solar cells composed of a thin GaAs film mechanically stacked onto interdigitated back contact Silicon solar cell with a glass interlayer have shown efficiency up to 32.6% [2]. The main advantage of such approach is that high quality III-V top cells could be monolithically grown on a GaAs substrate. Despite using costly GaAs wafers in the epitaxy of the III-V top cells increases the production costs, detach (by chemical lift-off) of the cells from the underlying substrates and multiple re-utilization of the latter have been demonstrated in the literature [3], as viable strategies to keep production costs low.
We present a study on the metalorganic vapor phase epitaxy (MOVPE) growth and structural-optical properties of GaAsP-based heterostructures on (100)GaAs, with the aim to fabricate a high efficiency 1.7 eV top cell for utilization in a stacked 4-terminal tandem III-V/Si solar cells. Despite GaAsP epilayers grown by MOVPE are commonly used in the fabrication of (In)GaAs-based heterostructures for applications to solar cells and laser diodes, not so much as been reported to date on growth details and related structural (strain, pleastic relaxation) and radiative (luminescence) properties of tensile-strained GaAsP epilayers on GaAs. In this work P incorporation into GaAsP alloys has been determined along with the solid-vapor distribution curve as function of growth temperature by employing tertiarybuthylarsine and tertiarybuthyl-phosphine as As and P precursors respectively, in combination with trimethylgallium. Analysis of as-grown samples by high-resolution X-ray diffraction evidenced the elastic deformation state of the material and the onset of plastic deformation, which turned out to agree well with what expected from People-Bean relaxation model (values of critical thickness turned out to range up to few-hundreds nanometer) [4]. Low temperature photoluminescence spectra further showed a near band-gap emission for most GaAsP samples. Examples of high quality (pseudomorphic) step-graded GaAsP buffer layers on (100)GaAs will be finally reported.

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[1] F. Dimroth, S. Kurtz, High-efficiency multi-junction solar cells, MRS Bulletin **2007**, 32, 230.
[2] R.C. Whitehead, K.T. VanSant, E.L. Warren, J. Buencuerpo, M. Rienacker, R. Peibst, J.F. Geisz, A.C. Tamboli, Optimization of four terminal rear heterojunction GaAs on Si interdigitated back contact tandem solar cells, Appl. Phys. Lett. **2021**, 118, 183902.
[3] C.-W. Cheng, K.-T. Shiu, N. Li, S.-J. Han, L. Shi, D.K. Sadana, Epitaxial lift-off process for gallium arsenide substrate reuse and flexible electronics, Nat. Comm. **2013**, 4, 1577.
[4] R. People, J.C. Bean, Calculation of critical layer thickness versus lattice mismatch for GexSi1−x/Si strained-layer heterostructures, Appl. Phys. Lett. **1985**, 47, 322.

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