Stacked GaAs(Sb)(N)-capped InAs/GaAs quantum dots for enhanced solar cell efficiency

A.D. Utrilla, J.M. Ulloa, Ž Gačević, A. Guzman and A. Hierro
ISOM and Dpto.Ing.Electrónica, Universidad Politécnica de Madrid, Spain
E-mail: jmulloa@isom.upm.es

Different approaches have arisen aiming to exceed the Shockley-Queisser efficiency limit of solar cells. Particularly, stacking QD layers allows exploiting their unique properties, not only for intermediate-band solar cells or multiple exciton generation, but also for tandem cells in which the tunability of QD properties through the capping layer (CL) could be very useful.

On one hand, GaAsSb CLs have been reported to strongly improve the optical properties of InAs/GaAs QDs [1]. On the other hand, using GaAsN compensates the accumulated strain allowing the stacking of a larger number of QD layers [2]. Therefore, using a GaAsSbN CL could, in principle, take advantage of both approaches, as well as from the independent control of the QD-CL conduction and valence band offsets, which would allow designs that facilitate carrier extraction from the QDs.

We have studied the impact of using thin (~ 5 nm) GaAs(Sb)(N) CLs on the photocurrent characteristics of stacked InAs/GaAs-QDs embedded in the intrinsic region of a p-i-n junction. A comparative analysis among samples using GaAsSbN and both ternary counterparts has been carried out. The molecular bean epitaxy growth conditions of GaAsSbN are found to be particularly critical and, therefore, different growth approaches for the CL are analyzed by means of structural and optical characterization techniques.

Different strategies to engineer the band structure, such as electronically coupling the periodic QD-CL structure or using a type-II band alignment are discussed, as well as the effect of rapid thermal annealing on device performance. Moreover, critical parameters like the overall strain (obtained from X-ray diffraction measurements) are correlated with the optoelectronic properties.

[1] J. M. Ulloa et al., Phys. Rev. B 81, 165305 (2010).
[2] R. Oshima et al., Appl. Phys. Lett. 93, 083111 (2008).