Gallium nanoparticles for improved III-V solar cells

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Abstract

In the last decade, third generation solar cells have progressed very strongly in efficiency, which is a key metric in the development of photovoltaic systems to reduce the cost of electricity per kilowatt-hour. The short-circuit current (J_{SC}) and the open-circuit voltage (V_{OC}) of the solar cell are the two main factors that should be considered to have an optimized efficiency. Some materials show moderate J_{SC} values that indicate that better light management must be applied to improve the solar cell. This includes better coupling and trapping of light above the cell and reduction of light absorption in inactive regions of the cell [1]. In this work, we report on the improved performance of GaAs solar cells via light scattering from gallium nanoparticles (Ga NPs) deposited atop the devices. After minimal nanoparticle size optimization to tune its plasmonic effect, J_{SC} derived from external quantum efficiency measurements is increased around 18%, revealing a higher light collection. We also demonstrate a similar efficiency enhancement in III-V solar cells made of GaAsSb/GaAsN superlattices. This structure [2] is designed to form the lattice-matched 1.0–1.15 eV subcell that would allow the implementation of the optimum monolithic 3 and 4-junction solar cell structure. Theoretical calculations made with COMSOL Multiphysics software and detailed reflectance spectroscopy measurements reveal the role of the NP size and plasmonic effect in each case. Compared to the complex antireflective coatings used in the literature, this work shows an easier method that can be implemented insitu after growth of the solar cell.

References

[1] Harry A. Atwater, Albert Polman, Nature Materials, 9 (2010) 205-213
[2] A. Gonzalo *et al*, Solar Energy Materials and Solar Cells, 210 (2020) 110500

Figures

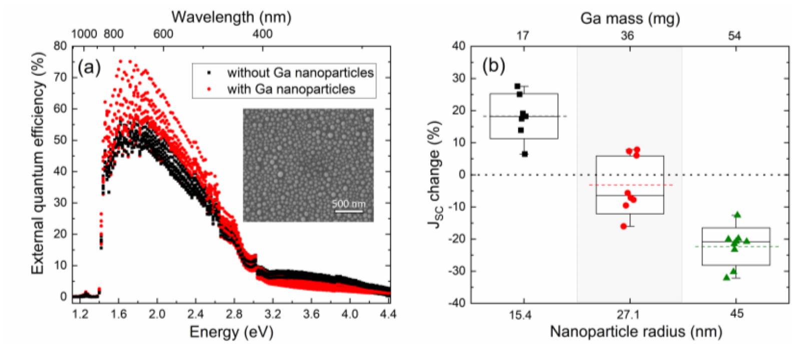

Figure 1: (a) External quantum efficiency (EQE) of different GaAs solar cells before and after Ga NPs deposition. (b) Short-circuit density current (J_{SC}) change (%) for different NPs radius atop the solar cells.