Admittance spectroscopy of Ga(In)P(NAs) based solar cells grown on silicon

A.I. Baranov[1,2], A.S. Gudovskikh[1,3], E.V. Nikitina[1], J.P. Klieder[2], A.Darga[2]

[1] St Petersburg Academic University of RAS, St.-Petersburg, Russia.

[2] Le Laboratoire de Génie électrique et électronique de Paris, Paris, France.

[3] St Petersburg Electrotechnical University "LETI", St.-Petersburg, Russia.

Dilute nitrides Ga(In)P(NAs) are the new type of materials, which have excellent perspectives for modern optoelectronics devices, for example, high-efficiency solar cells (SC). The introduction of 0.43% nitrogen into the GaP lattice makes this alloy to be a direct-gap semiconductor [1,2]. Furthermore, addition of indium and arsenic atoms allows one to vary band gap in the range of 1.5-2.0 eV with lattice-matched to silicon growth. It is the necessary condition for development of high-efficiency multijunction SC on Si subctrate. However, experimental research demonstrates low lifetime of minority carriers in donor-doped active layers of Ga(In)P(NAs) [3], so p-i-n structures could be more useful for photovoltaic applications, because pulling electric field prevents carrier recombination in space charge region. Therefore, the properties of undoped layers of dilute nitrides are the important issue for optoelectronic devices.

In our work, we study intrinsic layers of Ga(In)P(NAs) in double-junction solar cells grown on silicon substrates by molecular-beam epitaxy. Four solar cells were grown with different undoped active layers of $GaP_{0.70}As_{0.30}$, $GaP_{0.98}N_{0.02}$, superlattice of $GaP_{0.99}N_{0.01}$/InP and $GaP_{0.882}N_{0.018}As_{0.10}$. We used admittance spectroscopy to study defect properties of Ga(In)P(NAs) layers. No defect response was observed for GaPAs layers without any nitrogen content. However, two defects B2 and B3 with activation energy 0.20…0.23eV and 0.05eV respectively were defined in GaPN layers. Defect B2 was detected in GaPN/InP and GaPNAs layers with lower (by factor of 2-4) concentration, while defect B3 was not detected in these layers. We suggest that defects origins due to nitrogen incorporation into GaP or due to bombardment of samples by nitrogen, because it was not detected in GaPAs layer. On the other hand, indium and arsenic incorporation improves properties of GaPN layers: it allows one to compensate elastic stresses appearing during nitrogen incorporation and his local clustering. Moreover, addition of arsenic is preferable, because it incorporates into sublattice of V groups atoms while indium is element of III group. It leads to improvement of photoelectrical properties in GaPNAs layers compared to superlattice GaPN/InP.

References.

1. W. Shan, W. Walukiewicz, K. M. Yu, J. Wu, J. W. Ager, E. E. Haller, H. P. Xin, and C. W. Tu, Appl. Phys. Lett. **76**, 3251 (2000).

2. I. A. Buyanowa, G. Pozina, J. P. Bergman, W. M. Chen, H. P. Xin, and C. W. Tu, Appl. Phys. Lett. **52**, 81 (2002).

3. J. F. Geisz, J. M. Olson, D. J. Friedman, K. M. Jones, R. C. Reedy, and M. J. Romero, in Proceedings of the 31st IEEE Photovoltaic Specialists Conference PVSC2005 (Orlando, USA, 2005), p. 695