Abstract

In thesis “Optical properties of novel III-V-N alloys” optical properties of phosphorus-based dilute nitrides were studied using variety of spectroscopy technique. Influence of small concertation (< 3%) of nitrogen atoms on electronic band structure was studied. Band Anticrossing Model was used as a theoretical explanation of electronic band structure.

Phosphorus-rich GaNP and GaNPAs samples with N content of 0.5 – 2.5% and As ≤ 40 were studied by modulation spectroscopy. It was confirmed that incorporation of a few percent of N atoms has a drastic effect on the electronic structure of the alloys. Moreover, the change of the electronic band structure may be very well described by the Band Anticrossing model. It is shown that incorporation of a few percent of nitrogen into P-rich GaPAs leads to formation of intermediate band and the change of the nature of the fundamental band gap from indirect to direct. The direct band gap in GaNPAs alloys has been confirmed by absorption and PL measurements. In addition, direct optical transitions between the valence band and the upper conduction band (E+ transition) have been clearly identified in optical CER spectra. The observed formation of the isolated intermediate band offers a potential of using P-rich GaNPAs alloys for intermediate band solar cells.

Doped, n-type and p-type $GaN_xP_yAs_{1-x-y}$ alloy were studied by photoreflectance measurements. Optical transitions related to three absorption bands: VB $\rightarrow$ IB, VB $\rightarrow$ CB, and IB $\rightarrow$ CB, have been identified in PR spectra. It was confirmed that doping has influence on the intensity of VB$\rightarrow$IB and IB$\rightarrow$CB absorption in $GaN_xP_yAs_{1-x-y}$ alloy.

Temperature dependence of the band gap was investigated. The results from optical absorption studies of GaNP and GaNPAs were analyzed. The temperature absorption edge studies in a wide temperature range of 20 – 310 K reveal an effect of thermal stabilization of the band gap that is explained by the BAC interaction between temperature- and composition-independent N level and the conduction band states of the GaP(As) host matrix that results in a creation of E_- bands. The weak sensitivity to the temperature variation of the energy gap was found potentially advantageous both for solar cells and laser devices where it is possible to significantly reduce the environment temperature change related efficiency fluctuation.

The properties of emission form phosphorus rich GaNP and GaNPAs structure were studied and led to conclusion that localization energy exists in these alloys and depends on the composition. The emission properties (energy, intensity, FHWM) were studied intensively which is important to find the optimal parameters in the case of the optical applications.