The dielectric functions and chemical and atomic compositions of the near surface layers of implanted GaAs by In$^+$ ions

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The dielectric functions $\varepsilon(E)$, atomic surface concentrations and chemical compositions have been studied in the near surface layers of the implanted GaAs before and after thermal treatment. The surfaces of semi isolating GaAs have been irradiated by In$^+$ ions with the energy 250 keV and fluences were in a region from $1\times10^{13}$ cm$^{-2}$ to $3\times10^{16}$ cm$^{-2}$. The irradiated samples were isobaric annealing at 800°C during 2h. The depth profiles of the atomic surface concentrations were measured with the help of Rutherford backscattering spectrometry and nuclear reactions RBS/NR. It was noticed two processes in the all study samples. The first was diffusion indium atoms to the irradiated surfaces and second effect was change of the surface atomic concentration of oxygen atoms in the native oxide layers covered the implanted GaAs. The functions $\varepsilon(E)$ were investigated in the photons energy region from 1.3 eV to 5.0 eV. The depth profiles of $\varepsilon(E)$ were obtained of the removable chemical layers for the all study sample. Several effects were observed in the measured spectra. They were associated with the formation of amorphous layers and the disappearance of bounds $E_1$ and $E_1+\Delta_1$ associated with critical points CP. The reconstruction of these bands has been observed in the spectra collected for the all samples after thermal treatment. The parameters of these bands were different for the samples irradiated with different fluences and at various depths from the surface. These effects may be explained by the reconstruction of the GaAs crystallographic structure damaged in varying degrees in the implantation process. During the process of thermal annealing InAs was formed in the near surface layers of the samples implanted with the fluences $3\times10^{15}$ cm$^{-2}$, $1\times10^{16}$ cm$^{-2}$ and $3\times10^{16}$ cm$^{-2}$. This effect was noticed during the measurements with the help X-ray photoelectrical spectroscopy (XPS) of the study samples after the thermal treatment process. These disordered layers in the implantation process were reconstruction and indium atoms formed with displacement atoms of GaAs the new chemical compound InAs. In addition, these processes influenced the formation of the natural oxides of different chemical composition and different optical constants. It has been found that amounts of InO$_2$ and relative amounts Ga$_2$O$_3$/As$_2$O$_3$ increase in the native oxide layers with the fluences before the thermal treatment of the samples. It was observed the amounts of Ga$_2$O$_3$ did not change after the thermal annealing and they were approximately on the same level as before the process. In addition, it was subordinated that the quantity of As$_2$O$_3$ decreases in the all native oxide layers after the thermal treatment. The study showed that the use of the methods SE, RBS/NR, and XPS allows for a more precise definition of the dielectric function of the near surface layers of irradiated GaAs.