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ACCUMULATION AND ANNEALING OF RADIATION DONOR DEFECTS IN ARSENIC–IMPLANTED $Hg_{0.7}Cd_{0.3}Te$ FILMS*

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The most common method of the fabrication of a p^+–layer in *n*–type $Hg_{1-x}Cd_xTe$ (MCT) with the aim of the development of 'p^+–*n*'-type photodiodes is ion implantation of arsenic followed by a two-stage activation annealing. The latter treatment is used for the annealing of radiation-induced defects and for the electrical activation of implanted ions. Fabrication of the photodiodes with ultimate parameters requires the knowledge of the processes of accumulation and annealing of the radiation-induced defects. Studies of these processes were performed earlier on MCT films with the composition of the active layer x_a~0.22, which serve as a basis for the fabrication of LWIR photodiodes. In this work, we report on the results of similar studies performed on MCT films with x_a~0.30, which are suitable for the development of MWIR devices.

The studies were performed on films with *p*– (due to the presence of mercury vacancies, acceptors in MCT) and *n*–type conductivity of the photodiode 'base'. The films were grown by Molecular Beam Epitaxy on GaAs and Si substrates and their active layers were covered with graded-gap surface layers (GSL). Implantation was performed with arsenic ions with energy 190 and 350 keV and fluences ranging from 10^{12} to 10^{15} cm^{-2}. The electrical characterization of the implanted films was performed by studying the magnetic field *B* dependences of the Hall coefficient $R_H(B)$ and conductivity $\sigma(B)$ at the temperature T=77 K. The data obtained in these studies were processed with the discrete mobility spectrum analysis, which allowed for obtaining the information on the set of carriers and their parameters, such as concentration, mobility and partial conductivity. Other methods of characterization included optical reflectivity studies in the VIS wavelength region and transmission electron microscopy; these were used for the study of radiation-induced damage, types of extended structural defects formed as a result of the implantation, and of their behavior under annealing.

It was found that implantation with the energy 190 keV and fluences 10^{12}–10^{15} cm^{-2} in the films with *p*–type base resulted in the formation of either an 'n^+–*p*' or a 'n^+–*n*–*p*' structure. The exact type of the structure was defined by the concentration of residual donors, which were responsible for the formation of the *n*–layer. Implantation with ion energy 350 keV lead to the formation of n^+–*p* structures for all the fluences used. In similar MCT structures with x_a~0.22, arsenic implantation with ion energy 190 keV and fluences 10^{12}–10^{15} cm^{-2} always resulted in the formation of 'n^+–*n*–*p*' structures.

It was found that the main structural defects in radiation-damaged layers were dislocation loops of various sizes. The dominating contribution to conductivity (~80% of the total conductivity) in the implanted films was due to electrons with low mobility (2500 – 4000 cm^2/(V·s) belonging to the n^+–layer formed as a result of implantation. These electrons originate in donor centers formed when the loops captured atoms of interstitial mercury. In films with x_a~0.3 we observed rather weak dependences of layered concentration and partial conductivity of the low-mobility electrons on the ion fluence. These values reached the saturation points at the fluence of 10^{13} cm^{-2}. In MCT films with x_a~0.22, the saturation was not observed at fluences as high as 10^{15} cm^{-2}; this difference resulted from lower internal electric field induced by GSL in the films with x_a~0.3.

The activation annealing of films with x_a~0.3 resulted in full annihilation of the loops (in contrast to films with x_a~0.22, where after the annealing the loops transformed into single dislocations), and, as a consequence, in the disappearance of the low-mobility electrons. Also, in nominally un-doped structures with x_a~0.3 with *n*–type base we did not observe the recovery of the electrical parameters of the base after the second stage of the activation annealing, which means that fabrication of photodiodes on the basis of this material requires a donor doping of the base.

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