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DISTRIBUTION PROFILES OF RADIATION DONOR DEFECTS IN ARSENIC-IMPLANTED HgCdTe FILMS

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Currently, the most promising design of *p–n* junctions used in photodiodes based on HgCdTe (MCT), the basic material for infrared photo–electronics, relies on fabrication of local *p*–type regions in an *n*–type base with the use of ion implantation of arsenic [1]. Such p^+–*n* junctions demonstrate smaller dark currents than their n^+–*p* counterparts, and this allows for increasing the operating temperature of photodiodes or for extending their photosensitivity cut-off wavelength. Ion implantation, however, leads to the formation of various types of radiation donor defects, so to form a required *p*–type region one needs to anneal the defects and to activate the introduced arsenic atoms electrically. To perform an effective annealing, it is necessary to know the exact nature of the donor defects and their location in the implanted material. For arsenic implantation in MCT such knowledge is not yet available, so the task of this work was to investigate distribution profiles of radiation donor defects in arsenic-implanted MCT.

The studies were performed on films grown with molecular-beam epitaxy on Si substrates with ZnTe/CdTe buffer layers. The films were doped with indium during the growth and initially had *n*–type conductivity with electron concentration at the temperature T=77 K, $n=3.9\cdot10^{15}$ cm^{-3}. They were brought to *p*–type with hole concentration $p=5.1\cdot10^{15}$ cm^{-3} via annealing at low mercury pressure (such annealing generates mercury vacancies, acceptors in MCT). After the annealing, the films were implanted with arsenic ions with 190 keV energy and 10^{15} cm^{-2} fluence. Electrical parameters of the films after the growth and annealing, as well as the distribution of electrically active radiation donor defects after the implantation were determined by studying magnetic field B dependencies of the Hall coefficient $R_H(B)$ and conductivity $\sigma(B)$ at T=77 K in B=0.01–1.5 T range with step-by-step chemical etching of the material. The obtained $R_H(B)$ and $\sigma(B)$ dependencies were analyzed with the use of discrete mobility spectrum analysis (DMSA) [2], which allowed for determining the types of carriers and their parameters (mobility, average concentration n_{av} and average partial conductivity σ_{av}, reduced to the whole thickness of the etched layer) after every etching step.

It was established that after ion implantation an n^+–*n*–*p* structure was formed, at its conductivity was contributed by three types of electrons with different mobilities. In particular, the n^+–layer was formed by extended and quasi-point donor defects (represented by electrons with low and intermediate mobility), while a thin (~ 1 µm-thick) *n*–layer (electrons with high mobility) was formed as a result of diffusion of interstitial mercury atoms and their annihilation with mercury vacancies. On the basis of the values of n_{av} and σ_{av} we calculated layered concentration N_s and layered partial conductivity Σ_s for each type of electrons at each etching step. The calculated values of N_s and Σ_s were used to plot the volume electron concentration and partial conductivity for each type of carriers against the thickness of the etched material.

The analysis of the obtained dependencies allowed for determining the distribution of radiation donor defect in arsenic-implanted HgCdTe films grown with MBE. In particular, low-mobility electrons (~5000 cm^2/(V·s)), which gave dominating contribution to the conductivity, appeared to be located in a layer with 400 nm depth; this layer coincides with the area of localization of extended structural defects and implanted arsenic ion profile [3]. These electrons are likely related to donor defects formed when interstitial mercury is captured by dislocation loops. Intermediate-mobility electrons (~20000 cm^2/(V·s)) are located down to the depth of 700 nm. They are related to defect complexes formed by interstitial mercury with various point defects. High-mobility electrons (~90000 cm^2/(V·s)) are located in *n*–layer extending beyond the depth of 700 nm. The obtained results clarify the details of defect structure of arsenic-implanted MCT and can be useful for the developers of MCT-based photo–electronic devices.

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