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INVESTIGATION OF THE EFFECT OF SOFT X-RAY RADIATION ON THE ELECTROPHYSICAL CHARACTERISTICS OF EPITAXIAL LAYERS *n*-$Hg_{1-x}Cd_xTe$ [1]

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Earlier it was shown that soft X-ray radiation (SXR) of laser plasma leads to a modification to the modification of surface morphology [1] of single crystals and epitaxial layers of $Hg_{1-x}Cd_xTe$ solid solutions. When studying the capacitance-voltage (C-V) characteristics of MIS structures created on the surface of irradiated epitaxial layers *p*-$Hg_{0.77}Cd_{0.23}Te$ [2] and *n*-$Hg_{0.81}Cd_{0.19}Te$ [3], changes in the carrier concentration and the density of the built-in charge were observed, which can be associated with the generation of radiation defects in the near-surface region during irradiation. The nature of these defects for the studied material has been little investigated. In this work, the influence of SXR on the electrophysical properties of MIS structures based on *n*-$Hg_{0.76}Cd_{0.24}Te$ epitaxial layers is studied.

The investigated heteroepitaxial structures based on *n*-$Hg_{0.76}Cd_{0.24}Te$ were grown by the method of molecular beam epitaxy (MBE) on GaAs (013) substrates in the ISP SB RAS. The working layer 15 μm thick was surrounded on both sides by the graded-gap layers with a thickness of about 0.3 μm with a CdTe content on the surface equal to 0.45. The plasma of a laser-induced vacuum spark containing quanta with energy in the range 0.5÷10 keV was used as a source of SXR. The spectrum of the generated SXR consisted of plasma bremsstrahlung and recombination characteristic radiation of excited ions of cathode material and extended to 10 keV. To cut off visible radiation and fluxes of corpuscular particles, a filter (aluminized mylar with a thickness of 3 μm) was transparent in the region above 0.75 keV. The calculated irradiation doses of the test samples were up to 1.5 J/cm^{-2}. The duration of the X-ray pulse did not exceed 200 ns.

MIS structures were created after irradiation by plasma-enhanced atomic layer deposition of Al_2O_3 insulator onto the epitaxial layers. In wide ranges of temperatures (9-77 K) and frequencies (1-2000 kHz), the admittance of MIS structures was investigated by the methods described in [4]. The measurements were carried out on an automated setup of admittance spectroscopy based on the Janis cryostat and the Agilent E4980A immittance meter.

Determined from capacitive measurements electron concentration at 77 K non-monotonically increases with the irradiation dose. In the absence of SXR irradiation, the electron concentration was 2.6×10^{15} cm^{-3}, and at the maximum dose (1.5 J/cm^{-2}) reached 3.9×10^{15} cm^{-3}. Investigations of the C-V curves showed that the SXR leads to a change in the spectra of the fast surface states of MIS structures. These changes are non-monotonic with increasing doses. The reason for the described effects is the alteration of the impurity-defective system of the insulator-semiconductor interface and the near-surface layer of the semiconductor, the presence of a dose-dependent dependence of the effects indicates their radiative character.

One of the most probable mechanisms for their occurrence is defect formation in the decay of electronic excitations. Probably, the primary effect of SXR interaction with a solid solution of HgCdTe is the excitation of internal electron shells of Hg ions, which is accompanied by an external photoelectric effect. As a result, a triply charged Hg^{3+} ion is formed, whose lifetime is limited by the Auger effect and is estimated at 10^{-13} s. As the model of defect formation assumes in the decay of electronic excitations during this time, as a result of the Coulomb interaction, an ion with an additional charge can move to the interstitial space forming a vacancy or complex (vacancy and atom in the interstitial space).

REFERENCES

[1] *Средин В.Г., Ананьин О.Б., Бурлаков И.Д., Мирофянченко А.Е., Мелехов А.П., Новиков И.К.* // Прикладная физика. – 2013. – № 6. С.17–20.

[2] Войцеховский А. В., Несмелов С. Н., Дзядух С. М, Средин В. Г., Ананьин О. Б., Мелехов А. П., Сидоров Г. Ю. // Известия вузов. Физика. – 2016. – Т. 59. – № 9/2. С.198–201.

[3] *Средин В.Г., Войцеховский А.В., Ананьин О.Б., Мелехов А.П., Несмелов С.Н, Дзядух С.М., Юрчак В.А.* // Прикладная физика. – 2017. – № 5. С.59–63.

[4] *Voitsekhovskii A.V., Nesmelov S.N., Dzyadukh S.M.* // Journal of Physics and Chemistry of Solids. – 2017. – V. 102. P. 42-48.

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