

Position state of copper atoms in EL2-Cu complex structures of gallium arsenide crystal

M.B.Litvinova, O.N.Lebed'

Institute of Semiconductor Physics, National Academy of Sciences
of Ukraine, 45 Nauki Ave., 03028 Kyiv, Ukraine

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Effect of vacancy composition of gallium arsenide single crystals on the passivation of anti-structure EL2 defects by copper atoms due to EL2-Cu complexes has been studied. Copper in those complexes has been shown to occupy preferably gallium vacancies.

Изучено влияние вакансионного состава монокристаллов арсенида галлия на пассивацию антиструктурных дефектов EL2 атомами меди в результате образования комплексов EL2-Cu. Показано, что в составе этих комплексов медь, преимущественно, занимает вакансии галлия.

Copper introduction into gallium arsenide single crystals results in passivation of anti-structure EL2 defects due to formation of electrically inactive EL2-Cu complexes [1, 2]. Since Cu atoms either occupy gallium vacancies (Cu_{Ga}) or are in interstices (Cu_i) of the GaAs crystal lattice, those may be present in the complexes as Cu_{Ga} or as Cu_i . The predominant position state of copper is, however, unknown. In this work, we have studied the EL2 defect passivation in the copper diffusion zone in GaAs single crystals at different concentration ratio between gallium vacancies and arsenic ones. It is shown that copper in EL2-Cu complexes occupies mainly gallium vacancies.

The initial study objects were semi-insulating undoped (SIU) GaAs single crystals of n conductivity type. The crystals were grown by Czochralski technique at the (100) orientation and have the resistivity $\rho = 7 \cdot 10^7$ to $2 \cdot 10^8 \Omega \cdot \text{cm}$. The EL2 center concentration as determined from optical absorption of $h\nu = 1.04$ eV light quanta [3] was $N = (1.4 \text{ to } 2.0) \cdot 10^{16} \text{ cm}^{-3}$. The vacancy composition of the crystals (concentration ratio between gallium and arsenic vacancies, $z = [V_{\text{As}}]/[V_{\text{Ga}}]$) was determined from intensity ratio between low-temperature

(77 K) photoluminescence (PL) bands: the edge one with the emission maximum at $h\nu_m = 1.51$ eV and extrinsic one, with $h\nu_m = 1.49$ eV, due to radiative transition from the conductivity band to the acceptor C_{As}^{1-} level (Fig. 1) [4, 5]. Copper was introduced into about 2 mm thick samples at 850°C for 30 min followed by the sample quenching. The diffusion was carried out from gas phase generated by evaporating a copper weight of 20 mg placed into quartz ampoules with about 4 cm^{-3} operating volume evacuated previously down to less than 10^{-3} Pa.

The distribution of physical characteristics near the crystal surface after the Cu diffusion was determined in zone of the p conductivity type and linear recombination of carriers using the layer-by-layer sample etching by anodic oxidation under additional illumination [6]. The passivation extent of EL2 defects was found basing on the PL band with maximum at $h\nu_m \approx 0.65$ eV ($I_{0.65}$) being the spectral sum of bands having $h\nu_m = 0.63$ eV and $h\nu_m = 0.68$ eV bands (dashed lines in Fig. 1). The first band is due to trapping of free electrons by charged EL2^+ centers while the second one, by trapping of free holes by neutral EL2^0 centers. The major current carrier concentration was