Functional Materials 10, No.4 (2003)

Copper-induced change in luminescence quantum yield through EL2 centers in GaAs single crystals

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Received January 14, 2003

A change in the intensity ratio of luminescence bands induced by EL2 defects is observed in GaAs crystals as a result of copper atoms entering. The effect has been shown to be of threshold character depending on the measurement temperature. The effect value is defined by the crystal vacancy composition. The mechanism of emission intensity change through the EL2 centers is considered basing on transition of the centers into metastable $EL2^*$ state due to influence of $Cu_{Ga}V_{As}$ complexes.

Установлено, что в кристаллах GaAs в результате введения атомов меди наблюдается изменение соотношения интенсивностей полос люминесценции, индуцируемых дефектами EL2. Показано, что в зависимости от температуры измерений эффект носит пороговый характер. Величина эффекта определяется вакансионным составом кристаллов. Рассмотрен механизм изменения эффективности излучения через центры EL2, основанный на переходе последних в метастабильное состояние $EL2^*$ под влиянием комплексов $Cu_{Ga}V_{As}$.

The EL2 anti-structure defects are known to cause the emission bands peaked at 0.63 eV and 0.68 eV in the long-wavelength region of gallium arsenide crystals photoluminescence (PL) spectra [1]. The first band is due to capturing of free electrons by charged $EL2^+$ centers while the second one, to free hole capturing by neutral $EL2^0$ ones. The integral intensity ratio of those bands ($I_{0.63}/I_{0.68}$) is defined by internal quantum efficiencies of their emission, η^+ and η^0. In the stationary case, under the intrinsic luminescence excitation, $I_{0.63}$ should be equal to $I_{0.68}$ (i.e., $\eta^+ = \eta^0$) [1]. Consideration of several works [1–4] shows that a significant difference between $I_{0.63}$ and $I_{0.68}$ is often observed in PL spectra of GaAs crystals, the nature of this phenomenon remains still unclear. In this work, it will be shown that a considerable intensity change of $h\nu_m$ = 0.63 eV and $h\nu_m$ = 0.63 eV bands may result from copper atom diffusion and the effect value depends on the crystal vacancy composition.

Copper was diffused into semi-insulating undoped (SIU) gallium arsenide crystals of *n*-type conductivity grown by Czochralski technique with (100) orientation and specific resistance (ρ) of $7\cdot10^7$ to $2\cdot10^8$ Ω·cm^2. The EL2 center concentration therein (N_{EL2}) was determined from optical absorption of 1.04 eV light quanta (absorption coefficient $k_{1.04}$). It is know [5] that at this energy, the photoionization cross-sections of $EL2^+$ and $EL2^0$ centers (σ_p and σ_n, respectively) are the same ($\sigma_p = \sigma_n = \sigma = 4.9\cdot10^{-17}$ cm^2). The light absorption coefficient of EL2 defects (k_{EL2}) is related to concentrations N^+_{EL2} and N^0_{EL2} by simple relationships $k_{EL2} = k_{1.04} = \sigma_p \cdot N^+_{EL2} + \sigma_n \cdot N^0_{EL2} = \sigma \cdot N_{EL2}$, thus making it possible to find $N_{EL2} = N^+_{EL2} + N^0_{EL2}$ from known $k_{1.04}$ [6]. In this work, N_{EL2} was (1.4 to 2.0)$\cdot10^{16}$ cm^{-3}.