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Ground and Excited States of Excitons in GaSe Single Crystals

Ecaterina Cristea, Ivan Stamov, Victor Zalamai

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Abstract

Gallium selenide is a layered crystal with outstanding nonlinear optical properties. Due to layered structure and weak van der Waals bonds it is perspective as two dimension material. GaSe possesses two-phonon absorption and can be uses in THz diapason. Investigation of optical properties is important for further development of optoelectronic devices on its base. In this work photoluminescence, reflection and absorption spectra of GaSe single crystals were studied in a wide temperature range (10 – 300 K). The presence of series of excitonic levels in the region $E > E_g$ was shown. At excitation by 448 nm laser of GaSe crystal electrons were resonantly excited from $V_1(\Gamma_1)$ band to $C_1(\Gamma_6)$ and $C_2(\Gamma_5)$ bands. The luminescence from excitonic levels (nA = 1, 2 … 5) of conduction band $C_1(\Gamma_6)$ to valence band $V_1(\Gamma_1)$ was observed. Recombination from excitonic level of $C_1(\Gamma_6)$ band to V_2 and V_3 bands (maxima n^B = 1–2.1751 eV and n^B = 2–2.2222 eV) and to V_4 and V_5 bands (maxima n^C = 1 – 2.311 eV and n^C = 2–2.350 eV) was observed. Luminescence maxima n^D = 1 (2.399 eV) and n^D = 2 (2.434 eV) attributed to transitions between $C_1 – V_6$, V_7 bands and E_3 maximum caused by recombination $C_2 – V_1$ were found out. A model of energy bands responsible for observed transitions was suggested.

Keywords: gallium selenide, excitonic states, band structure, photoluminescence, wavelength modulation reflection spectra

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