Electron-phonon interaction in emission centers formed by impurity Pr^{3+} and Dy^{3+} ions in cadmium tungstate crystals

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In despite of repeated observation of electron-phonon interaction (EPI) manifestations in spectra of Rare-earth (RE) ions, its investigation has some difficulties. Lines responsible for transitions involving lattice's phonons are characterized by low intensity for the centers formed by RE ions. Experimental have shown both ion and covalence interactions of local luminescence center with the neighborhood increase EPI, but prediction about prevailing role of one of these factors is impossible. Thus, a new experimental data concerning EPI displaying is an important for the development of modern theory of interaction between electron transition and lattice's phonons in a local center.

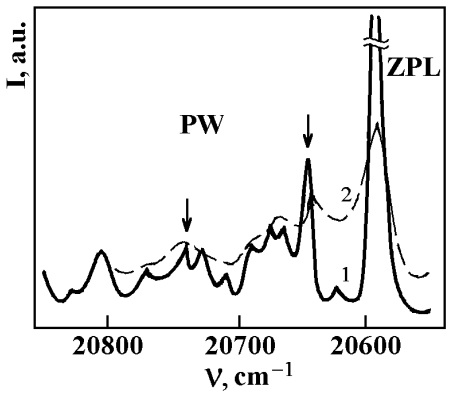

Fig. 1. Absorption spectra of $CdWO_4$:Pr^{3+} crystal (C = 1 mass %), T = 4,2 K (1) and 295 K (2) on the region of $^3P_1$, $^3P_0 \leftarrow {}^3H_4$ transition

One of the main exhibitions of EPI is a spectral observation of phonon wings - broad bands formed by phonon repetitions of a pure electron transition - besides narrow spectral zero phonon lines (ZPL) of RE ions. Analysis of phonon wings (PW) of photoluminescence spectra of the Pr^{3+} doped $CdWO_4$ crystals gives values for ν_{ph} = 44, 62 and 114 cm^{-1}. The most distinctive PW in the absorption spectra of these crystals were observed at 4,2 K for the $^3P_0 \leftarrow {}^3H_4$ and $^3P_1 \leftarrow {}^3H_4$ electron transitions in Pr^{3+} ions (Fig.1). Lines in PW are overlapping and forming structured bands with separated components. Increasing of a temperature leads smearing noted bands for both transitions. We have estimated Deby-Waller factor for the lines of $^3P_1 \leftarrow {}^3H_4$ transition as $\alpha = I_{ZPL}/(I_{PW}+ I_{ZPL}) = 0,4$.

Observed manner of electron-phonon band formation is corresponded to the model describing arising of PW as a result of relative shifting of equilibrium positions of electron states interacted in the electron transition. This manner have some symptoms: pumping off intensity from ZPL to PW with temperature increasing; raise of multiphonon transitions contribution in the structure and intensity of PW at both increasing of Stoks's losses and temperature.

Comparison of obtained characteristics for impurity Pr^{3+} ions in the $CdWO_4$ crystals with data for impurity Pr^{3+} ions in other matrices shows our results principally agree with previous results for different types of crystals that confirms made conclusions about displaying transitions with lattice's phonon interactions.

Properties of EPI in luminescence centers in $CdWO_4$ crystals doped with Dy^{3+} ions was also studied in the experiment on photoexcitation of luminescence with ν_{ex} lower than frequency of corresponded electron transition in absorption. I(T) intensity and η(T) yield of luminescence increases with temperature increasing up to 220 K and have maximums at 220 K. We have explained this anomalous behavior of luminescence characteristics by two photon excitation of observed emission. Performed calculation gives the energy of additional photon taking part in this case in two-photon excitation of luminescence ν_{ph} = 120 cm^{-1}. The calculated value of ν_{ph} is closed to frequency of $CdWO_4$ lattice's phonon (114 cm^{-1}). Therefore, this result allow us to establish interaction of inner electron transition in impurity ions with host lattice's phonon in Dy^{3+} doped $CdWO_4$ crystals.