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Energy Spectra of the Tunable Laser Crystal $Gd_3Ga_5O_{12}:Cr^{3+}$ and Their Pressure-Induced Shifts

MA Dong-Ping[1,2]

[1] Department of Applied Physics, Sichuan University, Chengdu 610065, China
[2] International Centre for Materials Physics, Academia Sinica, Shenyang 110015, China
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Abstract: By means of both the theory for pressure-induced shifts (PS) of energy spectra and the theory for shifts of energy spectra due to electron-phonon interaction (EPI), at 300 K, the `pure electronic' contributions and the contributions from EPI to R_1 line, R_2 line, and U band of $GGG:Cr^{3+}$ as well as their PS have been calculated, respectively. The total calculated results are in good agreement with all the experimental data. Their physical origins have been explained. It is found that the mixing-degree of $|t_2^2(^3T_1)e\ ^4T_2>$ and $|t_2^{32}E>$ base-wavefunctions in the wavefunctions of R_1 level of $GGG:Cr^{3+}$ is considerable under normal pressure, and the mixing-degree rapidly decreases with increasing pressure. The change of the mixing-degree with pressure plays a key role for PS of R_1 line or R_2 line. At 300 K, both the temperature-independent contribution to R_1 line (or R_2 line or U band) from EPI and the temperature-dependent one are important. The remarkable difference between pressure-dependent behaviors of PS of R_1 lines of $GGG:Cr^{3+}$ and $GSGG:Cr^{3+}$ results from the differences of their microscopic properties. The features of emission spectra of $GGG:Cr^{3+}$ at various pressures have satisfactorily been explained.

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Key words: high-pressure effect, line shift, spin-orbit interaction, electron-phonon interaction, d-orbital, tunable laser crystal

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