Impact of Random Strains on Shapes of Spectral Lines and Quantitative Control of Laser Crystals Quality

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Point defects in crystals, such as vacancies, interstitial or substituted ions, induce long-range strain fields in the crystal lattice. Random strains bring an inhomogeneous broadening and a fine structure of spectral lines of optical centers. Theories of these spectral effects were derived using the approximation of the elastically isotropic continuum [1,2]. The advanced approach will be presented allowing us to analyze shapes of spectral lines in real elastically anisotropic crystals containing low concentrations of point defects and to evaluate defect strengths and concentrations from the measured high-resolution optical spectra. The generalized multi-dimensional distribution function of the strain tensor components induced by point defects in the elastically anisotropic continuum is derived. The distribution widths are expressed through the integrals over arrays of strains on the sphere of unit radius containing a defect at the center which are computed according to the theory developed in [3]. Our work contributes to the development of quantitative spectroscopic methods of the quality control of laser crystals. As an example, comprehensive experimental and theoretical studies of the concentration-dependent shapes of spectral lines with a specific narrow dip at the line center corresponding to singlet-doublet transitions in the Tm^{3+} ions doped into tetragonal orthooxides YVO_4, YPO_4, $LuVO_4$ and $LuPO_4$ were undertaken. The defect strengths of the impurity thulium ions, contributions of the intrinsic lattice defects into the strain fields as well as the concentrations of these defects are estimated.

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References

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