Physico-Chemical nanomaterials science

Optical investigation of the metal ions diffusion into $LiNbO_3$

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The diffusion of Cu and Fe ions is used for photorefractive elements formation as well as for modification of refractive index in lithium niobate ($LiNbO_3$, LN) single crystal near-surface layers for obtaining of integral optics structures [1]. The aim of this paper is a determination of peculiarities of Cu or Fe ions incorporation into LN crystal in different crystal-physics directions. The samples of LN 7(X)×15(Y)×32(Z) mm with polished surfaces were prepared from the LN boule. These samples were placed into CuO or Fe_2O_3 powder and annealed in air at 1073 K. After cooling the transmission spectra were registered in Z direction (300…1500 nm range). A shift of the absorption edge to longer wavelengths and formation of a weak broad band in visible and near IR region are observed after annealing. For measuring of optical absorption changes perpendicularly to the direction of metal ions diffusion, the polished 1 mm-thick plates were cut from the central part of annealed samples. The special designed unit was used for measuring of the plates absorption spectra through the 100 μm diameter aperture with the step of 20 μm. The sequential difference spectra (in relation to the optical absorption of the central part of the plates) were obtained at different points of the plates during scanning from their centers to the edges. The bands that excite Cu^+, Cu^{2+}, Fe^{3+} ions absorption were observed in these spectra. The values of the absorption in these bands maxima vary with the distance from the edges to the center of plates and characterize the concentration of Cu^+, Cu^{2+}, Fe^{3+} ions. The spatial distributions of copper and iron ions concentration in different crystal-physics directions in $LiNbO_3$ were calculated in accordance with Smakula-Dexter formula [2] based on the oscillators strengths of corresponding optical transitions.The dependences of the concentration maxima positions on the ion type and the crystallographic direction are discussed. The possible mechanisms of copper and iron ions incorporation into LN crystal are considered.

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