Nanocomposites and nanomaterials

Effect of Nd^{3+} ions on phase transformations and microstructure of 0-4 at.% Nd^{3+}:$Y_3Al_5O_{12}$ transparent nanoceramics

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Neodymium doped yttrium aluminum garnet (1-4 at.%) Nd^{3+}:$Y_3Al_5O_{12}$ laser ceramics were obtained by the reactive sintering method using commercial α-Al_2O_3, Y_2O_3, and Nd_2O_3 powders as starting materials, and SiO_2, ZrO_2 as a complex sintering aid. Phase composition and microstructure of Nd^{3+}:$Y_3Al_5O_{12}$ substitutional solid solutions were studied by XRD, SEM, XPS and UV-Vis spectrophotometry methods. The regularities for entering of iso- (Nd^{3+}) and heterovalent (Si^{4+}, Zr^{4+}) impurities into the garnet structure were revealed based on an assumption of formation of substitutional solid solutions. The influence of impurity point defects on optical properties of Nd^{3+}:$Y_3Al_5O_{12}$ laser ceramics was studied.

It has been determined that for *2.88*Y_2O_3–*0.12*Nd_2O_3–*5*Al_2O_3 powder system the temperature range of the formation of substitutional solid solution $(Y_{0.96}Nd_{0.04})_3Al_5O_{12}$ during the solid-state synthesis is 1350-1500 °C. It has been shown that the interaction of $(Y_{1-y}Nd_y)AlO_3$ and $(Nd_{1-z}Y_z)AlO_3$ (y, z≤0.02) monoaluminates with alpha-alumina dominates in the final stage of $(Y_{0.96}Nd_{0.04})_3Al_5O_{12}$ synthesis.

XPS results for 1-4 at. % Nd^{3+}:$Y_3Al_5O_{12}$ laser ceramics confirmed that Nd^{3+} ions were effectively incorporated into the garnet matrix and participated in the chemical bonding. The dopant concentration in 4 at. % Nd^{3+}:$Y_3Al_5O_{12}$ ceramics coincides with a nominal one. The linear dependence of the lattice parameter *a* on the concentration of Nd^{3+} ions in 1-4 at.% Nd^{3+}:$Y_3Al_5O_{12}$ ceramics correlates with theoretical calculations and indicates the formation of the isomorphic substitutional solid solutions $(Y_{1-x}Nd_x)_3Al_5O_{12}$ (x=0.01-0.04) with minor accumulations of the lattice defects. Sintered 2 at.% Nd^{3+}:YAG ceramics show in-line optical transmission of about 83.5 % at the lasing wavelength of neodymium ions (λ=1.064 μm) for 2.5-mm-thick samples; this value is comparable with that for single crystals of similar composition.