Impact of Annealing on Carbon Doped YAG and YAG:Ce Crystals

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$Y_3Al_5O_{12}$ (YAG)-based crystals are used in different applications due to the favorable combination of their properties, such as thermal conductivity, hardness, chemical stability, transparency. Doped with Ce, or Pr ions, YAG possesses attractive luminescent properties. The production cost is another important criterion in the material choice.

In the present work optical properties of YAG and YAG:Ce crystals grown in Mo crucibles under Ar+CO atmosphere are compared to those grown in Ir crucibles by the conventional technology. Effect of thermal annealing on YAG optical properties was studied on samples fabricated from the crystals grown in Ir crucible (YAG_{Ir}) under weakly oxidizing atmosphere and in Mo crucible (YAG_{Mo}) under reducing conditions. In the both cases the same batches of Al_2O_3 and Y_2O_3 powders with the purity 99.99 % were taken as the raw materials. Then, the samples fabricated from the $YAG_{\mathbf{Ir}}$ and $YAG_{\mathbf{Mo}}$ crystals were annealed under the reducing or oxidizing conditions. The absorption spectra of polished samples were registered. In parallel we measured the admixture content in crystals, including carbon, and element composition of the ~50 μm thick surface layer.

Following the growth under reducing conditions, $YAG_{\mathbf{Mo}}$ crystals have a deficiency by oxygen and aluminum. As-grown YAG_{Mo} crystals also contain carbon admixture, which affects their optical properties. Physico-chemical processes at the crystal surface, especially under the reducing conditions, should be accounted for as well at consideration of defects in garnet crystals [1].

Optimized post-growth annealing of such crystals provides irreversible discoloration of crystals and high transparency in the 200 – 1100 nm spectral range. The obtained results open new possibilities to optimization of properties of doped garnet crystals. The presence of active electron traps associated with carbon makes it possible to transfer an activator (for example, Ce, Pr, or Nd) into the optically active lower valence state by the reducing annealing thereby increasing a quantity of luminescence centers without loss of the crystal transparency.

[1] P. Arhipov, S. Tkachenko, S. Vasiukov, K. Hubenko, Ia. Gerasymov, V. Baumer, A. Puzan, P. Mateychenko, K. Lebbou, O. Sidletskiy, Features of YAG crystal growth under Ar+CO reducing atmosphere, *J. Cryst. Growth* **449** (2016) 104-107.