Crystal growth, morphology, and luminescence properties of selected multicomponent garnet single crystals for laser applications

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Tm- and Ho-doped multicomponent garnet laser crystals are intended for laser generation around 2 μm [1]. Due to the disordered structure of these multicomponent crystals, the absorption and emission lines of the doping ions are significantly spectrally broadened, which is advantageous both for efficient diode pumping and for wide laser tunability or for the generation of very short pulses in mid-infrared spectral region. Possible applications of such lasers include medical applications, high-resolution spectroscopy, and remote sensing. Moreover, the Tm^{3+} ions can be used as effective sensitizers for the Ho^{3+} ions responsible for laser action around 2.1-2.3 μm [1].
We have prepared three types of Tm, Ho-doped multicomponent garnet single crystals based on aluminum garnets
The concentration of Ho^{3+} was 0.75 at.% in all the cases, while the Tm^{3+} was either 2 or 4 at.%. The crystals were grown by the micro-pulling-down method [2, 3] using several types of crucibles. One was a classical crucible with 3 mm diameter circular shaped die with one 0.5 mm capillary. The crystals could be grown well without cracks or any visible inclusions. However, observations with a microscope under polarized light showed significant inhomogeneities deteriorating the optical properties of the samples and hampering the laser action. Therefore, we have changed the crucible design in a way that the 3 mm diameter die included a 2 mm diameter orifice enabling better contact of the melt and the emerging crystalline phase. Such a design led to the crystal homogeneity improvement and the resulting positive influence on the optical properties. We have also tested a conical crucible without a die with a simple 2 mm circular orifice in the conical bottom, where even better contact with the melt and the growing crystal could be achieved and the homogeneity was even further increased due to smaller crystal diameter and reduced thermal stress caused by steep temperature gradients usually present in the micro-pulling down growth process.
The details and peculiarities of the crystal growth of the Tm, Ho-codoped multicomponent aluminum garnet crystals, their morphology and homogeneity will be discussed in relation to the crucible design. The optical and luminescence properties will be shown and the capability of the laser action of selected crystals in the region of interest will be demonstrated.

References

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