Development of compositionally-tuned mixed-garnet crystals for space applications

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Abstract

There are considerable needs in space operations that call for the employment of specific laser sources under mandatory conditions such as high-power, appropriate function wavelengths, flexible lasing and pulse settings, tunability, narrowband, conversion efficiency, laser-beam control, and so on. In areas of space applications such as differential absorption lidar (DIAL), lasers particularly operated around the wavelength peak λ=943nm are recommended key solutions because their spectral emission straightforwardly matches the absorption line of water vapor in the Earth's atmosphere.

In the recent years, and as a result of the aforementioned prerequisites, groups of scientists started conducting central research to develop specific laser materials with valid output gain and efficiency suitable to bring about space constraints and preferences in an optical spectral range of interest. Part of the efforts are focused on the development of compositionally tuned crystals which can be obtained by adjusting the concentration of the host constituents in order to alter the spectral emission and shift it towards a particularly desirable wavelength. Mixed-garnet crystals are innovative materials appropriate for tuning a laser emission in the wavelength range λ=935-945nm. In this class of crystals, lanthanide and rare-earth elements share the structure matrix in proportionalities that are controlled during the crystal growth process.

This presentation reviews the jobs carried out on assorted mixed-garnet laser crystals produced in Italy by the industrial firm FILAR – Opto Materials (FOM), partly in the framework of space activity projects established by the European Space Agency, and partly on market demand based on prerequisite specifications to build up a series of diode-pumped solid-state lasers (DPSSL) with exceptional capabilities. The crystals considered in this study are the Nd-doped mixed-garnet composites GSAG (gallium scandium aluminum garnet), YAG-YSGG (yttrium aluminum garnet – yttrium scandium gallium garnet), and YSAG-GGG (yttrium scandium aluminum garnet – gadolinium gallium garnet).

The presentation reports on the crystal growth of these mixed-garnets, their structural and spectral characterization, fabrication of laser components, and, in some case, laser assessment. Comparison with the properties and performance of Nd:YAG crystals (produced by FOM) will also be enlightened where possible.