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Solid state chemistry of Ca and Cr in the processing of Cr^{4+}:YAG laser ceramics

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Lasers based on Nd:YAG are widely used in military, materials processing, medicine etc. These lasers consist on active element Nd:YAG and Q-switcher Cr^{4+}:YAG. A recent trend in manufacturing of such elements is replacing single crystals with ceramics of high optical quality. The innovation approach to manufacture the laser can be developed, when both elements made from ceramics. In this case, a combined block of the active element and Q-switcher (Nd:YAG-Cr^{4+}:YAG) can be obtained in one technological route that allows both decreasing laser size and avoiding several expensive technological stages. To realize this approach a harmonization of the sintering routes of both types of ceramics should be carried out. Up today the huge progress has achieved in the sintering of Nd:YAG ceramics of high optical quality while the production of the Cr^{4+}:YAG still remains more art than technology. To reveal the possibility of adjusting the sintering routes of Nd:YAG and Cr^{4+}:YAG ceramics, the solid state chemistry of the Ca and Cr ions that are used as main additives to produce Cr^{4+}:YAG ceramics has been investigated. The effect of Cr ion on the formation of Cr^{4+}:YAG ceramics has been investigated and was revealed that Cr ions enhanced the optical properties of the final ceramics due to the appearance of the intermediate, which lowering the rates of solid state reactions under sintering. The dual role of Ca as sintering and charge compensator for Cr^{4+} has been studied and optimal Ca concentration was determined. The kinetics of Cr^{3+} oxidation to the Cr^{4+} under air annealing has been investigated to maximize the Cr^{4+} amount in ceramics Cr:YAG. The significant difference between the ceramics and single crystal has been revealed. It was established that the limitation stage of Cr oxidation is oxygen diffusion in ceramics grains. The results obtained allow designing the combined sintering route of Nd:YAG and Cr^{4+}:YAG ceramics.

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