SYNTHESIS AND STUDY OF YAG:Ln FOR MULTIPHOTON 3D LITHOGRAPHY

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An increasing number of novel synthesized materials allows extensive studies for their use in additive manufacturing, especially offered by diverse optical 3D printing techniques. The structuring via laser multiphoton 3D lithography empowers miniaturization and integration for various applications. However, there is still a limited number of reports on the precise structurization of polycrystalline and transparent YAG ($Y_3Al_5O_{12}$). Research discussed in this study experimentally proves the possibility to synthesize and 3D micro-structure pure, crystalline, and transparent YAG substances which are opening micro-/nano-engineering of optically active devices such as micro-lasers and photonic integrated circuits (PICs).

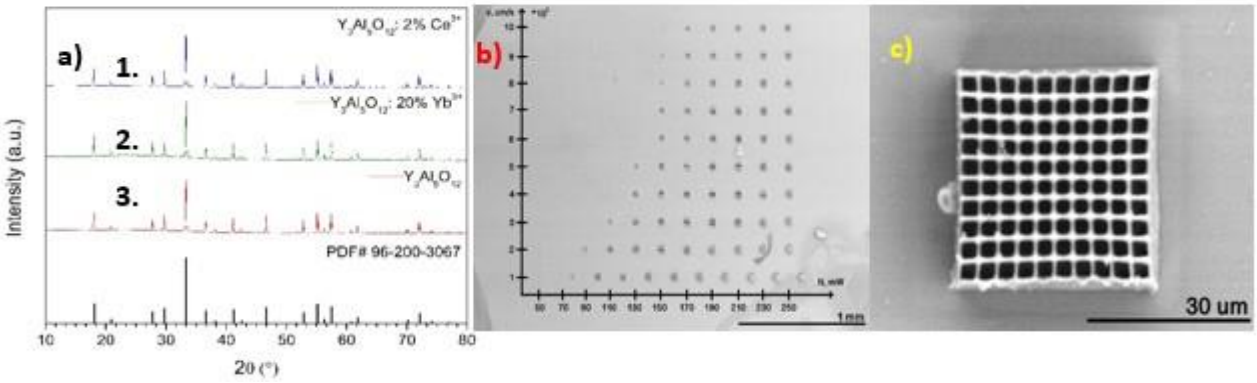

Figure 1. a) X-ray diffraction (XRD) patterns of: 1. YAG doped with 2% of Ce^{2+}, 2. YAG doped with 20% of Yb^{3+} and 3. undoped YAG; b) SEM image of 3D woodpiles fabricated with different exposure intensities (X-axis) and translation velocities (Y-axis); c) 2D top view of a single structure.

XRD patterns have shown that pure YAG is only obtained when samples were heated at 1600°C, since when heated at 600°C no crystallized YAG is formed and when heated at 1500°C some impurities remain. Structurization study of the material was performed while shifting laser irradiation power on X-axis from 50 mW to 250 mW and translation speed on Y-axis from 5000 µm/s to 10000 µm/s, with size of each formed woodpile 3D structure being sized 50 µm x 50 µm x 30 µm. After structurization samples were rinsed in ethanol and Novec™ 7100 for contrasting. SEM images of sample obtained without heating showed that most of the fabricated structures were intact, with some missing during after wet chemical development. Later annealing the sample at 600°C more structures had disappeared while others have shrunk due to the removal of organic fraction from the material. Finally, after calcinating the sample at 1600°C structures have fallen apart and melted, most likely due to the temperature being too high or sintering lasting for too long.

These results show, that while still further improvements of fabrication protocol are needed, it is already opening the pathway for additive manufacturing of optical grade active devices at micro- and nano-scales enabling geometrically non-restricted 3D architectures.

References:[1] G. Balčas, M. Malinauskas, M. Farsari, S. Juodkazis, Adv. Func. Mater. **33**(39), 2215230 (2023); [2] G. Merkininkaitė, et. al., Adv. Eng. Mater. **25**(17), 2300639 (2023).