High-pressure luminescence and Raman spectroscopy of the single crystalline films of $Ca_3Sc_2Si_3O_{12}$:Ce and $Ca_2YMgScSi_3O_{12}$:Ce garnets

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The phosphors based on single crystalline films (SCF) of Ce-doped Ca-Si-based mixed garnets, namely $Ca_3Sc_2Si_3O_{12}$:Ce (CSSG:Ce) and $Ca_2YMgScSi_3O_{12}$:Ce (CYMSSG:Ce) attract attention due their potential applications in various optoelectronic devices, particularly at the development of film and film-crystal phosphor converter for WLED [1, 2].

Using the liquid phase epitaxy (LPE) method, the CSSG:Ce and CYMSSG:Ce SCFs were grown onto GAGG and YAG single crystal (SC) substrates, respectively, with SCF/substrate misfit values of 0.25% and 2% [3]. The substantial difference in lattice constants between the films and substrates induces significant internal mechanical stresses, which could significantly affect the optical characteristics of the film phosphors. However, the impact of mechanical stress on the properties of SCFs, grown on different substrates, remains unexplored. By applying additional high external pressure to these epitaxial structures, it is possible to investigate the mechanical-optical coupling effects in SCF of LPE grown garnet compounds [4]. For this reason, in this work we focus on analyzing the luminescent properties of CSSG:Ce SCF/GAGG SC and CYMSSG:Ce SCF/YAG SC epitaxial structures at high-pressure range up to 16 GPa, using diamond anvil cells.
A critical aspect of the characterization of such composite materials is the description of the properties of the transition layer that forms between the SCF and the substrate during the LPE growth process. Anticipating the occurrence of high mechanical stresses in this area, it is worth examining their impact on the vibration and optical properties of the film materials. This study also used confocal Raman spectroscopy, analyzing the CSSG:Ce SCF/GAGG SC and CYMSSG:Ce SCF/YAG SC epitaxial structures from the surface of the SCF through the transition layer to the substrate, providing insight into the mechanical-optical interactions in these systems.

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