Study of thermal behavior glasses in system Al_2O_3-Yb_2O_3-Er_2O_3

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ABSTRACT

Aluminate glasses containing rare-earth elements Al_2O_3-RE_2O_3 (RE = Y, Yb, La) possess remarkable material properties (both chemical and physical) and a remarkable ability to absorb rare-earth dopants. Yb^{3+} doped materials are particularly ideal for highly efficient lasers due to the uncomplicated electronic level structure of the Yb^{3+} ion, which minimizes parasitic effects and maximizes the emission of Er^{3+} ions in materials. However, producing aluminate glasses with a high alumina content can be challenging due to their high melting temperatures and strong tendency to crystallize. To overcome this issue aluminate glasses can be prepared in the form of microspheres by flame synthesis.

The given work focuses on studying the thermal behaviour of glasses in the Al_2O_3-Yb_2O_3-Er_2O_3 system. The systems with a composition identical to YbAG (62.5 mol. % Al_2O_3 and 37.5 mol. % Yb_2O_3) were doped with various concentrations of Er^{3+} ions (2, 6 and 10 mol. %). The glass microspheres were prepared by flame synthesis from precursor powders synthesized by the modified Pechini sol-gel method. The amorphous nature of raw microspheres was confirmed by X-ray powder diffraction (XRD) and scanning electron microscopy (SEM). Differential scanning calorimetry (DSC) in temperature interval 30 – 1100 °C at different temperature rates (2, 4, 6, 8, 10 °C.min^{-1}) in N_2 atmosphere were performed for detailed study of thermal behaviour and for obtaining reliable data for the calculation of kinetic parameters. The crystallization kinetics of the samples were examined using models: Kissinger-Akahira-Sunosse (KAS), Ozawa-Flynn-Wall (OFW) and Friedman, and activation energy E_A and frequency factor A were determined. The highest E_A value was calculated for the sample with 10 mol. % of Er^{3+}. For a better understanding of the crystallization process, the isothermal crystallization experiments at 914 °C for 40 minutes were performed. The crystallized microspheres were studied by XRD and SEM analyzes. The XRD analysis confirmed the crystallization of the YbAG phase, and SEM analysis of cross-sections of microspheres showed the prevailing 3-D crystallisation in the whole volume.

Keywords: aluminate glasses, crystallization kinetic, thermal analysis

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