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Glass-Ceramics for Emission in the IR Region

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Abstract : Cr4+ doped oxide compounds are particularly preferred active media for solid-state lasers with a wide emission region from 1.1 to 1.6 μm. However, obtaining of single crystals of these compounds is often problematic. An alternative solution of this problem is replacing the single crystals with a transparent glassceramics containing the desired crystalline phase. Germanate compounds, especially Li2MgGeO4, Li2ZnGeO4 and Li2CaGeO4, are suitable for Cr4+ doped glass-ceramics because of their relatively low melting temperature and tetrahedral coordination of all ions. The latter ensures the presence of chromium in the 4+ valence. Cr doped Li2CaGeO4 g lass-ceramic was synthesized by thermal treating using glasses from the Li2O-CaO-GeO2-B2O3 system. Special investigations were carried out for optimizing the initial glasscomposition, as well as the thermal treated conditions. The synthesis of the glass ceramics was accompanied by appropriate characterization methods such as: XRD, TEM, EPR, UVVIS-NIR, emission spectra and time decay as main characteristic for the laser emission. From the systematic studies carried out in the four-component system Li2O-CaO-GeO2-B2O3 for establishing the Li2CaGeO4 crystallization area and suitable thermal treatment conditions, several main conclusions can be drawn: 1. The crystallization region of Li2CaGeO4 is relatively narrow, localized around the stoichiometric composition of the Li2CaGeO4 compound. 2. The presence of the glass former B2O3 strongly supports the obtaining of homogeneous glasses at relatively low temperatures, but it is also the reason for the crystallization of borate phases. 3. The crystallization of glasses during thermal treatment is related to the production of more than one phase and it is correct to speak for crystallization of a main phase and accompanying crystallization of other phases. The crystallization of a given phase is related to changing the composition of the residual glass and creating conditions for the crystallization of other phases. 4. The separate studies show that glass-ceramics with different crystallized phases in different quantitative ratios can be obtained from the same composition of glass playing by the thermal treatment conditions. In other words, the choice of temperature and time of thermal treatment of the glass is an extremely important condition, along with the optimization of the starting glass composition. As a result of the conducted research, an optimal composition of the starting glass and an optimal mode of thermal treatment were selected. Glass-ceramic with a main phase Li2CaGeO4 doped by Cr4+ was obtained. The obtained glass-ceramic possess very good properties containing up to 60 mass% of Li2CaGeO4, with an average size of nanoparticles of 20 nm and with transparency about 70 % relative to the transparency of the parent glass. The emission of the obtained glass-ceramics is in a wide range between 1050 and 1500 nm. The obtained results are the basis for further optimization of the glass-ceramic characteristics to obtain an effective laser-active medium with radiation in the 1.1-1.6 nm range.

Keywords : glass, glass-ceramics, multicomponent systems, NIR emission
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