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Interplay between phase transitions and thermoluminescence in BaAl2O4

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1. Introduction

   The Eu2+ and R3+ doped alkaline earth aluminates (MAl2O4; M: Ca, Sr, Ba) are among the best persistent luminescence materials [1]. The most efficient is, however, SrAl2O4:Eu2+,Dy3 – partly due to its emission in green to which the human eye is sensitive. Also the blue emitting CaAl2O4:Eu2+,Nd3+ is more efficient than the barium one. All three materials should have similar properties since they have the stuffed tridymite (SiO2) type structure. However, SiO2 is known for polymorphism and MAl2O4 derived from this do not behave dissimilarly. Although CaAl2O4 seems to have only one form and SrAl2O4 two, for BaAl2O4 one knows two hexagonal [2] and one orthorhombic forms. These polymorphs are found at high temperatures quite far from the usual operating range (<200 ℃) of persistent luminescent materials. Nevertheless, the role of possible low temperature phase transitions should not be excluded as a reason for the less good persistent luminescence performance of BaAl2O4:Eu2+(,R3+) [3,4]. Further studies were carried out by using the high-temperature X-Ray Powder Diffraction (HT-XPD), Differential Scanning Calorimetry (DSC) and thermoluminescence (TL) methods.

2. Results

The HT-XPD patterns of BaAl2O4 (Fig. 1) at room temperature (RT) correspond to the hexagonal P63 form. Additional weak reflections may indicate symmetry decrease to e.g. orthorhombic but this needs further proof. The RT structure is not stable for more than some 50 ℃ before significant changes occur in the intensity of all reflections. Characteristic to these changes is that they occur over a wide temperature range and smooth changes seem to be the rule rather than the exception. The intensity variation suggests displacement of atoms away from the reflection planes and changes may thus occur just in the space group. The DSC measurements were inconclusive since only a few broad signals and strong background variation were found instead of sharp signals. These features are in agreement with the slow and gradual nature of the changes in the XPD patterns. Both the HT-XPD and DSC results correlate well with the bands observed in the TL glow curves. When compared to the very simple (1 or 2 TL bands) glow curves of CaAl2O4:Eu2+ or SrAl2O4:Eu2+ (without R3+ co-doping), the five broad TL bands for BaAl2O4:Eu2+ between 100 and 400 ℃ (Fig. 2) indicate a more complex trap structure with energies from 0.8 to 1.4 eV. Thus a reason for the inferiority of the BaAl2O4 host vs. CaAl2O4 and SrAl2O4 is clear: the close to continuous distribution of traps does not allow long term storage of input energy but the bleaching of the traps occurs too rapidly. The persistent luminescence is then of short duration.

Are you currently a postgraduate student? (Yes/No)

No

Primary author: LASTUSAARI, Mika (University of Turku, Department of Chemistry,Turku, Finland)

Co-authors: Prof. SWART, Hendrik (University of the Free State); BRITO, Hermi F. (University of São Paulo, Institute of Chemistry, São Paulo-SP, Brazil); Prof. HÖLSÄ, Jorma (University of Turku); RODRIGUES, Lucas C.V. (University of Turku, Turku, Finland); LAHTINEN, Manu (University of Jyväskylä, Department of Chemistry, Jyväskylä, Finland)

Presenter: Prof. HÖLSÄ, Jorma (University of Turku)

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