Optical Materials 34 (2012) 1155–1160

Contents lists available at SciVerse ScienceDirect

Optical Materials

journal homepage: www.elsevier.com/locate/optmat

Fabrication and spectroscopic characterization of Ce^{3+} doped $Sr_2Y_8(SiO_4)_6O_2$ translucent ceramics

Yiqiang Shen [a], Rui Chen [b], Gagik G. Gurzadyan [b], Jinling Xu [c], Handong Sun [b], Khiam Aik Khor [c], Zhili Dong [a,*]

[a] Division of Materials Science, School of Materials Science and Engineering, Nanyang Technological University, Singapore 639798, Singapore
[b] Division of Physics and Applied Physics, School of Physical and Mathematical Sciences, Nanyang Technological University, Singapore 637371, Singapore
[c] School of Mechanical and Aerospace Engineering, Nanyang Technological University, Singapore 639798, Singapore

ARTICLE INFO

Article history:
Received 6 September 2011
Received in revised form 12 January 2012
Accepted 17 January 2012
Available online 9 February 2012

Keywords:
Translucent ceramics
Spark plasma sintering
Photoluminescence spectra
Energy transfer
Decay profile

ABSTRACT

Ce^{3+} doped $Sr_2Y_8(SiO_4)_6O_2$ translucent ceramics were successfully fabricated by spark plasma sintering and their photoluminescent properties were studied in correlation with the crystal structure. There are two crystallographic sites A^I and A^{II} for Ce^{3+} in the $Sr_2Y_8(SiO_4)_6O_2$ host and according to the analysis of the photoluminescence spectra, the energy levels of Ce^{3+} at A^I and A^{II} sites were demonstrated by the configurational coordinate model. The spectroscopic characteristics also indicated that the energy transfer from Ce^{3+} at A^I to those at A^{II} occurred. This energy transfer became more pronounced with higher Ce^{3+} doping concentration, which is confirmed by the analysis of decay profiles.

1. Introduction

The transparent and translucent ceramics have great potentials to replace their single crystal counterparts and apply as the laser medium and scintillators due to the easier fabrication process and better mechanical properties [1–3]. Ceramics usually consist of randomly oriented grains and in order to fabricate transparent ceramics, the light scattering centers including pores, impurity phases, rough surfaces and grain boundaries must be minimized or eliminated [4]. The scattering by impurity phases can be excluded by using pure raw materials. The scattering at surfaces can be suppressed by careful polishing. To eliminate the pores in the ceramic, advanced sintering methods such as hot pressing, [5] hot isostatic pressing [6] and vacuum sintering [7] is necessary. More recently, another sintering technique – spark plasma sintering (SPS) drew more attention due to its rapid heating rate and the combination of mechanical pressure, higher vacuum and electric field during sintering [8]. The scattering at grain boundaries is mainly due to the birefringence effect, which results from the different refractive indexes of the grains at both sides of the boundary [9]. Therefore, the pore-free ceramics in non-cubic crystal structures, whose refractive indexes are anisotropic, always have lower transmittance than those with cubic structures and appear translucent. Previous study about spark plasma sintered silicate oxyapatites with a hexagonal crystal structure has shown that the pores in these ceramics can scatter the incident light much more severely than the birefringence [10]. Therefore, translucent ceramics of silicate oxyapatites can be produced by suppressing the pores.

In the aspect of applications, translucent ceramics of Ce^{3+}:Lu_2SiO_5, Ce^{3+}:$SrHfO_3$ and Eu^{3+}:Lu_2O_3 have been produced and demonstrated prospective applications as scintillators [11–15]. All these ceramics have been fabricated by hot pressing technique or vacuum sintering but the time-efficient spark plasma sintering. Moreover, very few studies on ceramic forms of Ce^{3+} doped silicate apatites have been reported since single crystals of Ce^{3+} doped silicate oxyapatites were grown and used in scintillators for X- and gamma-radiation [16]. Based on our previous studies [10], it is believed that Ce^{3+} doped silicate apatite translucent ceramics can be fabricated by SPS sintering as well. The present work reports the SPS processing of these translucent ceramics, followed by a detailed study on their photoluminescent properties.

2. Experimental

Silicate oxyapatites $Sr_2Y_{8-x}Ce_x(SiO_4)_6O_2$ ($x = 0.01$, 0.05 and 0.1) powders were prepared through solid state reaction. Stoichiometric amount of $SrCO_3$ (>99.0%, Alfa Aesar), silica gel 60 (>99.0%, Fluka), CeO_2 (>99.95%, Sigma–Aldrich) and synthetic nano-sized Y_2O_3 were

---

* Corresponding author.
E-mail addresses: SHEN0061@ntu.edu.sg (Y. Shen), CHEN0529@ntu.edu.sg (R. Chen), GURZADYAN@ntu.edu.sg (G.G. Gurzadyan), JLXU@ntu.edu.sg (J. Xu), HDSUN@ntu.edu.sg (H. Sun), MKAKHOR@ntu.edu.sg (M. Khor), ZLDONG@ntu.edu.sg (Z. Dong), ZLDONG@ntu.edu.sg (Z. Dong).

0925-3467/$ - see front matter © 2012 Elsevier B.V. All rights reserved.
doi:10.1016/j.optmat.2012.01.020