Recent Research in Science and Technology 2012, 4(8): 119-120
ISSN: 2076-5061
Available Online: http://recent-science.com/

Mechanoluminescence properties of $SrAl_2O_4$: Tb^{3+} phosphor

Sanjay Kumar Sao , Nameeta Brahme , D. P. Bisen , Geetanjali Tiwari , Shalinta Tigga , Ishwar Prasad Sahu and Ugendra Kurrey

School of Studies in Physics and Astrophysics, Pt. Ravishankar Shukla University Raipur, Chhattisgarh, India

Abstract
Through the execution of experimental investigation, Mechanoluminescence of $SrAl_2O_4$:Tb^{3+} phosphor was studied which is synthesized by combustion method. In the observation, the peak value of ML depends on the different impact velocity. It was seen that at 55 cm height, the maximum peak of ML is obtained.

Keywords: Mechanoluminescence, Combustion Synthesis, Strontium Aluminate

INTRODUCTION

Among various host matrix materials, aluminates are considered to possess high energy efficiency, wide excitation wavelength range, and high quenching temperature. Strontium aluminate ($SrAl_2O_4$) has been paid much attention owing to its higher radiation-resistance and thermal stability. A particular selection of the dopants and codopants, may increase the duration of persistent luminescence from seconds to hours. As we know, Tb^{3+} is an activator for green luminescent materials and has been used widely in tricolour energy saving fluorescent lamp. In resent years, the experiments methods, such as sol-gel-microwave process, co-precipitation, combustion reaction or microwave combustion methods have been investigated to fabricate aluminates. Among these methods, combustion reaction is attractive because of low synthesis temperature and short reaction time. [1]

Mechanoluminescence (ML) is an important physical phenomenon where an emission of light is observed due to mechanical deformation of materials when they are subjected to some mechanical stress. This phenomenon has been observed in many kinds of solids including ionic crystals, semiconductors, metals, glasses and organic crystals.

This phenomenon is attracting considerable attention because of various important applications such as impact sensors, fracture sensor, damage sensor, sensor for stress etc. Mechanoluminescence of the crystals explain the crack propagation in crystals, and the basic mechanism of crack growth. In this paper we have reported the ML behaviour of Tb^{3+}-doped $SrAl_2O_4$ prepared by combustion synthesis at initiating temperature of 600 ^{0}C.[2].

EXPERIMENTAL

Analytical grade strontium nitrate $Sr(NO_3)_2$, aluminum nitrate $Al(NO_3)_3.9H2O$, terbium nitrate $Tb(NO_3)_3$ and urea $CO(NH_2)_2$ were used as the starting materials. Stoichiometric composition of the metal nitrates (oxidizers) and urea (fuel) were calculated using the total oxidizing and reducing valences of the components. Weighed quantities of each nitrate and urea were mixed together and crushed into mortar for 1 hour to form a thick paste. The resulting paste is transferred to crucible and introduced into a vertical cylindrical muffle furnace maintained at 600˚C. Initially the mixture boils and undergoes dehydration followed by decomposition with the evolution of large amount of gases (oxides of carbon, nitrogen and ammonia). The process being highly exothermic continues and the spontaneous ignition occurs. The solution underwent smoldering combustion with enormous swelling, producing white foamy and voluminous ash. The flame temperature as high as 1400 - 1600 ºC converts the vapor phase oxides into mixed aluminates. The flame persists for ~30 seconds. The crucible is then taken out of the furnace and the foamy product can easily be milled to obtain the precursor powder. The ML was monitored by a homemade setup having RCA 931 photomultiplier tube positioned below the Lucite plate and connected to a storage oscilloscope (Scientific 300 MHz, SM 340). Loads of different masses were dropped from fixed height [7].

RESULTS

Mechanoluminescence Study

Fig. 1 shows the characteristics of ML induced by the impact of a moving piston onto the phosphors. The luminescence intensity depends upon the impact velocity. The experiment was carried out for different heights dropped with same load.

i. It is seen that the luminescence intensity increases with increase in height of dropping load.
ii. The time duration of the maximum shifts towards lower values as the impact velocity is increased. (Fig. 2)

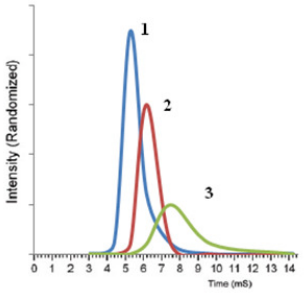

Fig 1.

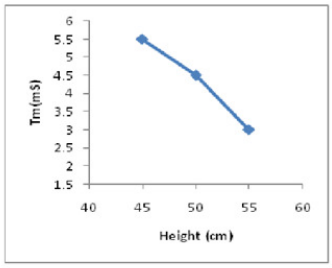

Fig 2.

Fig. 1 Mechanoluminescence behavior of $SrAl_2O_4$:Tb^{3+} when load of 400gm was dropped from different heights (1) 55cm, (2) 50cm, (3) 45 cm.
Fig. 2 Change in t_m with impact height

DISCUSSION

It is proved that the ML phenomenon of the Tb doped strontium aluminates are related to the movement of dislocations and the recombination of activated electrons and holes [5]. The

movement of dislocations excites carriers from the filled traps and the subsequent recombination of the electrons and holes in luminescence centers, which is doped Tb^{3+}, give rise to the deformation luminescence [6]. It is suggested that ML is produced by the transition of Tb-ions. The green emission of Tb^{3+} mainly originates from $^5D_4 \rightarrow {}^7F_j$ (J=0-6) transitions.

CONCLUSIONS

We have investigated the Mechanoluminescence phenomena in the $SrAl_2O_4:Tb^{3+}$. The phosphor was prepared by combustion method. It was found that ML intensity strongly depends upon the impact velocity.

REFERENCES

[1] Zhang Yanfang, LI Lan, Zhang Xiaosong, Wangdajian,Zhang Sasa, Preparation And Photoluminescence Of Tb3+ Doped Sral2o4 Phosphor By Composite Combustion Method, *Journal of Rare Earths,* Vol. 26, No. 5, Oct. 2008, P. 656.

[2] Anil Kumar Choubey, Nameeta Brahme, D. P. Bisen, Mechanoluminescence By Impulsive Deformation And Photoluminescence of $SrAl_2O_4$:Eu Phosphor Prepared By Combustion Synthesis, *Physics Procedia* 29 (2012) 104 – 108.

[3] Xu C N, Hiroshi Yamada, Xusheng Wang, Xu Guang Zheng. Strong Elasticoluminescence from Monoclinic Structure $SrAl_2O_4$, *Appl. Phys. Lett.,* 2004, 84(16), 3040.

[4] Hollerman W A, Bergeron N P, Goedeke S M, Allison S W, Muntele C I, D. Ila, Moore R J, Annealing Effects of Triboluminescence Production on Irradiated ZnS:Mn, *Surf. Coating Techno*l. 2007;201; 8382.

[5] Morito Akiyama, Chao-Nan Xu, Yun Liu, Kazuhiro Nonaka, Tadahiko Watanabe,"Influence of Eu, Dy co-doped Strontium Aluminate Composition of Mechanoluminescence intensity", *Journal of Luminescence* 97 (2002) 13-18.

[6] Morito Akiyama, Chao-Nan Xu, Kazuhiro Nonaka, "Intense Deformation Luminescence from Sintered $Sr_3Al_2O_6$: Eu", *Journal of Ceramic Society of Japan* 110, [11] 1029-1031 (2002).

[7] Nameeta Brahme, Manju Shukla, D.P. Bisen, U. Kurrey, Anil Choubey, R.S. Kher, Manisha Singh, "Mechanoluminescence by impulsive deformation of gamma-irradiated Er – doped CaF_2 crystals" *Journal of Luminescence* 131 (2011) 965-969.