Growth and Characterization of SrI_2:Eu scintillators

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Introduction

The search for high light yield and large volume single crystal scintillators with a low-cost potential and high-energy resolution for gamma spectroscopy has been intensified in recent years. Few materials have displayed extremely promising properties, including $LaBr_3$:Ce, $LaCl_3$:Ce, and alkaline earth halides. Among the alkaline earth halides, SrI_2:Eu scintillators are most promising in terms of properties and crystal growth. They are also closest to being a commercial product. The properties of SrI_2:Eu scintillators were first discovered by Robert Hofstadter [1]. Some of the excellent properties of SrI_2:Eu crystals include a high light yield (about 120 photons/keV), a good energy resolution (2.8% at 662 keV), scintillation decay time fast enough to avoid signal pile-up and emission wavelength in the quantum efficiency of most PMTs. SrI_2:Eu has a density of 4.55 g/cm^3, a high effective atomic number for a high gamma energy photoelectric absorption, and can be readily grown into a single crystal [2-4]. In this paper, we report on the successful growth and characterization of single crystals of SrI_2:Eu.

Experimental Details

Single crystal of SrI_2 doped with 5 mol% Eu was grown in silica ampoules using the vertical Bridgman technique. The melting point of SrI_2 is approximately 538°C. Anhydrous SrI_2 material (Aldrich, 99.99%), and EuI_2 powder (Aldrich, 99.9%), were used as starting materials. The starting materials were loaded into silica ampoules (conical bottom) in a nitrogen-purged glove-box. The ampoules were then closed from the atmosphere by use of a vacuum valve and subsequently connected to a Vac Sorb and rotary vane pump combination. The ampoules were evacuated to approximately 10^{-2} mbar while heated with a heater to approximately 150°C to remove any residual moisture. After several hours of heating the ampoule was sealed. The strontium iodide was kept cool during the entire sealing operation by wrapping a wet towel around the ampoule. This prevented thermal decomposition of the iodides due to heat from the torch.

Photoluminescence studies were performed over a wavelength range from 200 nm to 800 nm by employing an Edinburg fluorescence spectrometer (Model FLP920) in reflection geometry by positioning the samples (5x5x5 mm^3) at 45° with respect to the excitation beam. A xenon lamp was used as the excitation source and a spectral bandwidth of 0.3 nm was selected for both excitation and emission monochromators. All the recorded luminescence spectra were corrected for the spectral sensitivity function of the instrument. Fig.1 shows the emission and excitation spectra of ~5 mol% Eu doped SrI_2. The emission spectrum exhibits a narrow band (0.1 eV) centered at 433 nm while excitation spectrum shows a broad band (275nm to 440 nm) and there is an overlap in excitation and emission spectra that will lead to self absorption of emitted photons [5].

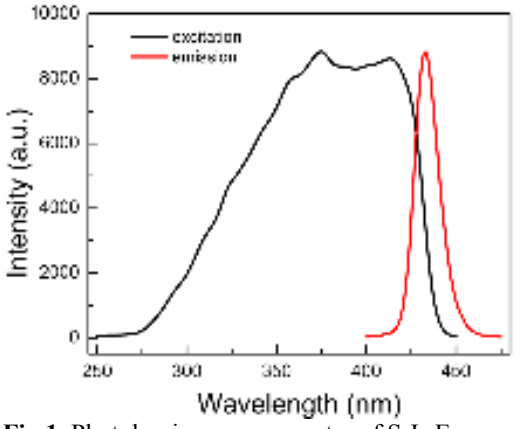

Fig.1. Photoluminescence spectra of SrI_2:Eu.

Radio-luminescence spectra were recorded with a Siemens X-ray tube having a Cu anode operated at 40 kV and 30 mA. The scintillation light was dispersed and recorded through an Avantes spectrometer AVASPEC 3648. The radio-luminescence spectrum along with the photo-luminescence spectrum is shown in Fig. 2. The spectrum consists of a single broad band due to Eu emission, peaking at 436 nm.

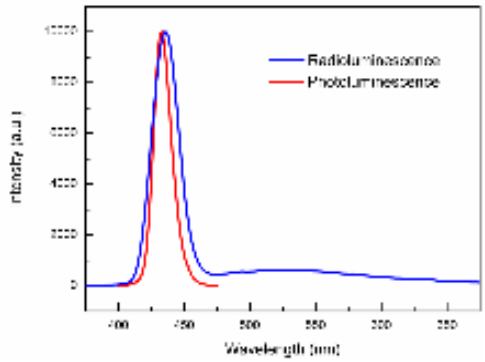

Fig.2: Radio-luminescence and photo-luminescence emission spectra of SrI_2:Eu

Scintillation decay time spectra were recorded using a ^{137}Cs gamma ray source and a Tektronix TDS 3102B oscilloscope connected to the output of a PMT. A simple exponential decay time model was used to fit the data. In the case of SrI_2 :5 mol% Eu, the scintillation decay curve can be described by a double exponential decay time model with a average time constant of 800 ns.

Pulse-height spectra were recorded with a Hamamatsu R2154 PMT. The output of the PMT was connected to a preamplifier and a spectroscopic amplifier (ECIL make PA4903). Crystals of 5x4x4 mm^3 were optically coupled onto the window of the PMT using silicone based optical grease. To minimize losses in light yield, the crystal was covered with a specially designed reflector made of spectralon. Fig. 3 shows the pulse height spectrum recorded using a ^{137}Cs gamma source with a shaping time of 3 μs. The energy resolution was found to be about 6% at 662 keV.

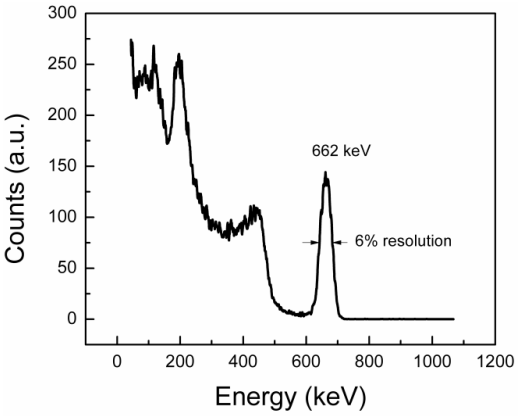

Fig.3: Pulse height spectrum of SrI_2: Eu under ^{137}Cs gamma ray excitation

Acknowledgement

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