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Temperature dependence of luminescence properties for Cs_2HfCl_6

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1. Introduction

Recently, novel halide-single-crystal scintillators for environmental gamma-ray spectrometers have been investigated in order to achieve the high light outputs and good energy resolutions. Halide-single-crystal materials generally have small band-gap energy than oxide scintillators have, and halide materials are expexted to have high light output and good energy resolution [1]. However, most of halide-single-crystal materials have hygroscopic nature, and some conventional halide scintillators such as Ce-doped $LaBr_3$, have intrinsic background, which is not suitable for gamma-ray spectroscopy under low dose rate.

Last year, as a non-hygroscopic halide-single-crystal material, Cs_2HfCl_6 was reported [2]. Cs_2HfCl_6 shows high light output (up to 54,000 photons/MeV) and good energy resolution (around 3.3%). In addition to these good scintillation properties, Cs_2HfCl_6 does not have intrinsic radiation and shows a large effective atomic number of 54. Thus, Cs_2HfCl_6 is considered to be the next-generational scintillation material for gamma-ray spectroscopy in several fields such as environmental dose monitoring in Fukushima.

In order to apply this material to the monitoring in the open air, investigation of temperature dependence of optical properties is required around -20 to 40 °C. However, its temperature dependence has been not reported yet. Thus, we report the properties in this paper. Moreover, we test the scintillation properties for not only pure Cs_2HfCl_6 , also emission-center-doped samples such as Na-doped Cs_2HfCl_6.

2. Experimental procedures

Crystal growth

Pure Cs_2HfCl_6 and Na:Cs_2HfCl_6 crystals were grown by the vertical Bridgman method as follows; As starting materials, 99.999%-pure CsCl, 98%-pure $HfCl_4$ and 99.999%-pure NaCl powders were used. These powders were packed into quartz ampoules in an argon environment in order to separate from atmospheric moisture. Quartz ampoules were sealed off. Sealed-off quartz ampoule was set to furnace and then heated by radio frequent induction heater.

Evaluation

After the crystal growth, we measured powder X-ray diffraction (XRD) analysis (Burker D8 DISCOVER) to confirm the phase. Emission and absorption wavelength of this sample were measured with following setup; the sample was excited by monochromatic UV photons using a Xenon lamp (150 W) and monochromator controlled by a computer. Using light fiber, the Cs_2HfCl_6 sample was excited with the UV light in an integrating sphere. Emission photons were measured using two spectrophotometers (Hamamatsu KK, PMA-12), consisting of Si-semiconductors. Using heater in the integrating sphere, we also measure the temperature dependence of optical properties such as emission wavelength and quantum yields for this sample. Moreover, its scintillation properties such as light output and decay times were investigated with a photo multiplier tube (Hamamatsu KK, R7600U-200).

3. Results

We succeeded in growth the pure Cs_2HfCl_6 and Na:Cs_2HfCl_6 crystals, and confirmed the single phase using XRD analysis. Emission wavelength of pure Cs_2HfCl_6 and Na:Cs_2HfCl_6 crystals were 415 and 410, respectively. Figure 1 shows the pulse height spectra for Na-doped Cs_2HfCl_6 and Tl-doped NaI scintillator as reference. The light output of the Na-doped Cs_2HfCl_6 was estimated to be 42,000 photons/MeV.

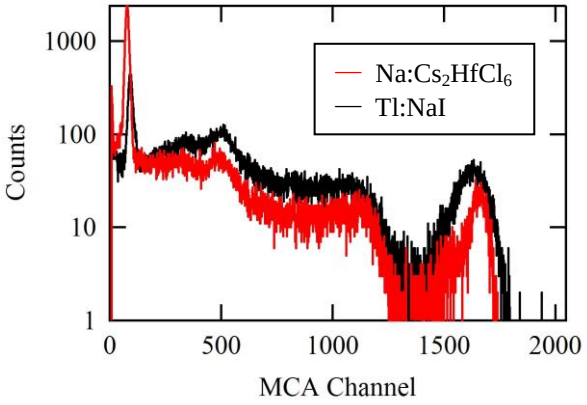

Fig.1 Pulse height spectra of Na:Cs_2HfCl_6 and Tl:NaI

4. Conclusions

We succeeded in growth the pure Cs_2HfCl_6 and Na:Cs_2HfCl_6 crystals, and these scintillators were found to have good light outputs. Moreover, their temperature dependences have been investigated. We show these results in this presentation.

References

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