Scintillation properties of $CdWO_4$ single crystal grown at KAERI

J.M. Park, H.S. Kim*, Y.S. Kim, J.H. Oh, C.G. Kang, S.M. Kim, A.H. Park, S.H. Lee
Advanced Radiation Technology Institute, Korea Atomic Energy Research Institute, Jeongup-si, Jeollabuk-do, Korea
**Corresponding author: khsoo@kaeri.re.kr*

1. Introduction

The cargo screening for contraband of arms, explosives and nuclear materials is important issue in a worldwide after 9.11 terror [1]. Also the TSA (Transportaion Security Administraion) in USA performed total inspection of air cargo by using radiation since 2010. Thus, the development and improvement of the security inspection scanner are needed. High energy X-ray and ɣ-ray are used in security inspection scanner for screening metal materials. Thus, the detector of cargo scanner is required with high detection efficiency for high energy X-ray or ɣ-ray [2].

Single crystal scintillators such as NaI:Tl, CsI:Tl, Bi4Ge3O12 (BGO) and CdWO4 are the primary radiation detector, and widely used in many radiation application field [3].

The cadmium tungstate, $CdWO_4$, is one of the candidates for applying cargo scanner system because it has a high effective Z-number (≈61) and high density (7.9 g/cm^{-3}) [4]. Other advantages of the $CdWO_4$ are good radiation hardness, chemical stability and non-hygroscopicity [5]. Thus, the $CdWO_4$ is widely applied to X-ray detection such as nuclear and high energy physics, homeland security, computed tomography (CT), and positron emission tomography (PET) [6].

We grew the $CdWO_4$ single crystal in oxidizing atmosphere by using the Czochralski method at KAERI (Korea Atomic Energy Research Institute). The scintillation properties of the $CdWO_4$, such as the emission wavelength, energy resolution, light yield and decay time, are studied.

2. Methods and Results

2.1 Crystal growth

Single crystal of $CdWO_4$ was grown from Pt crucibles heated inductively in oxidizing atmosphere by the Czochralski technique. The grown $CdWO_4$ crystal were Φ 20 X 100 mm^2 in dimensions. The grown $CdWO_4$ was annealed in the air over the temperature range of 1100 ℃, and then cut by diamond wire saw and polished with various SiC papers. Figure 1 shows a grown $CdWO_4$ single crystal (top) and polished samples (bottom). The dimensions of 2 samples were 10 X 10 X 2 mm^3 and 1 sample were 7 X 4 X 2 mm^3.

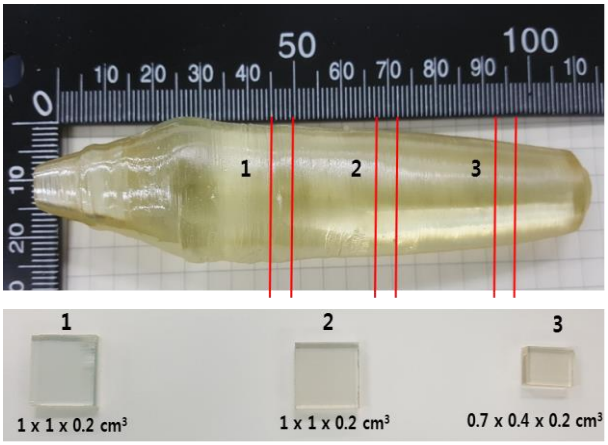

Fig. 1. A photograph of the $CdWO_4$ single crystal (Φ 20 X 100 mm^2) and polished samples.

2.2 X-ray excited emission spectra

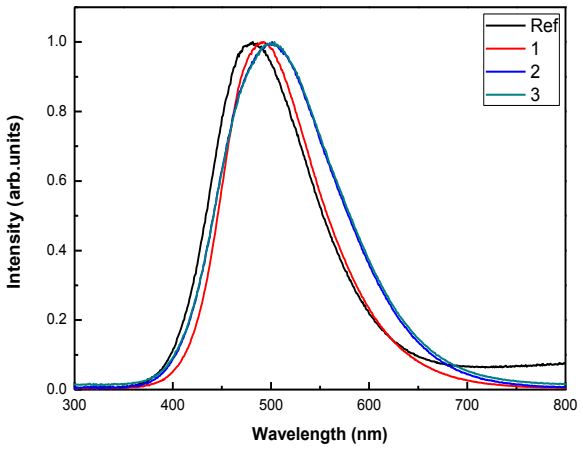

Fig. 2. X-ray induced emission spectra of $CdWO_4$ samples at room temperature.

Figure 2 shows the emission spectra of $CdWO_4$ crystals measured under X-ray excitation at room temperature. The emission wavelengths of grown $CdWO_4$ samples were compared with reference $CdWO_4$ sample from China. All samples showed broad emission bands between 400 nm to 700 nm. The emission peak of grown samples was 500 nm, but the reference $CdWO_4$ samples had maximum intensity at 480 nm.

2.3 Pulse height measurements

The pulse height spectra of grown $CdWO_4$ crystal under 661 keV ^{137}Cs ɣ-ray excitation are shown in Fig.3. The energy resolution (FWHM) was measured to be 11%. To estimate the light yield, the photo peak positions of grown $CdWO_4$ was compared with the reference CdWO4 (≈12,000 photons/MeV). The light yield of grown $CdWO_4$ was measured to be 8,520 photons/MeV, which is ~ 72% of the reference $CdWO_4$ crystal.

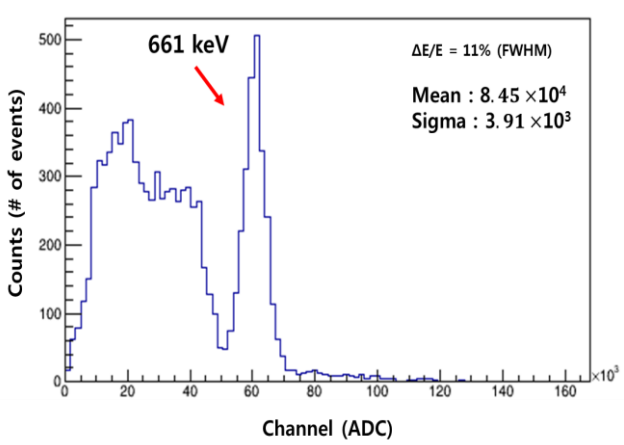

Fig. 3. The scintillation pulse height spectrum of $CdWO_4$ single crystal at room temperature excited 661 keV ɣ-ray from a ^{137}Cs source

2.4 Scintillation decay time measurement

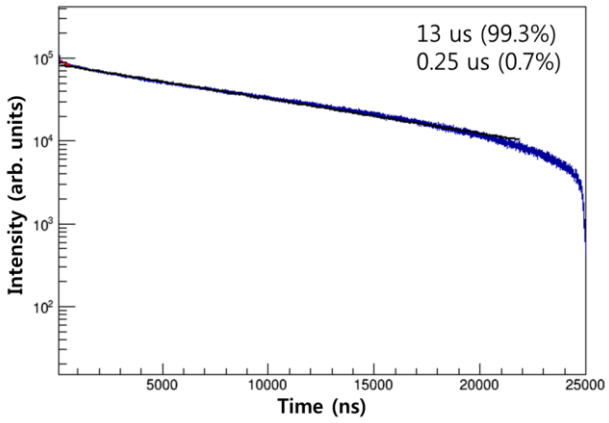

Fig. 4. The scintillation decay time spectrum of grown $CdWO_4$ sample at room temperature excited with 661 keV ɣ-ray from a ^{137}Cs source.

Figure 4 shows the ɣ-ray excited scintillation decay time curve of the grown $CdWO_4$ crystals recorded at room temperature. The decay time constant was measured to be 13 μs (99%) which is consistent with previous results [4].

3. Conclusions

In this experimental, the $CdWO_4$ single crystal was grown in oxidizing atmosphere by the Czochralski technique. As a result, not only the light yield of grown $CdWO_4$ was almost 70% of the commercial $CdWO_4$, but also other properties such as decay time, emission wavelength were similar with the commercial $CdWO_4$. Thus, we can check the possibility to applying for radiation detectors of medical imaging and cargo scanner. So, we have plan to improve the scintillation properties of the $CdWO_4$ by debugging growing conditions.

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