10th Eco-Energy and Materials Science and Engineering Symposium


On December 5-8, 2012
Sunee grand hotel,
Ubon-ratchathani

Organized by

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PREFACE:
Message from the President of
Rajamangala University of Technology Thanyaburi

Rajamangala University of Technology Thanyaburi (RMUTT), in conjunction with Kyoto University, is pleased to host the 10th Eco-Energy and Materials Science and Engineering Symposium (10th EMSES). This international conference is not only giving an opportunity for Thai and foreign researchers to present and discuss their research works and update their expertise but also to initially stimulate the development of research works on eco-energy and materials science and engineering. Our program consists of six research tasks: (1) Energy Technology, (2) Environmental and Social Impact, (3) Nanotechnology and Materials Science, (4) Energy Economics and Management, (5) New Energy technology and (6) Nuclear Technology.

I would like to take this opportunity to express our sincere gratitude to our two distinguished Plenary Speakers for kindly accepting our invitation. I deeply appreciate of the very strong support given by Kyoto University. Thanks to the tireless works of the Organizing Committee, the Technical Program Committee, the invited speakers and paper and poster contributors, and excellent program been assembled to cover a broad spectrum of interesting topic.

We warmly welcome you to the 10th EMSES on December 5-8, 2012, Ubon Ratchathani, Thailand.

Numyoot SONGTHANAPITAK, Ph.D.
President of Rajamangala University of Technology Thanyaburi andConference Chairman of 10th EMSES 2012
PREFACE:
Message from the Director of
Institute of Advanced Energy, Kyoto University

It is my great pleasure to have the 10th Eco-Energy and Materials Science and Engineering Symposium (EMSES) with Rajamangala University of Technology Thanyaburi (RMUTT) under the long-term collaboration between RMUTT and Kyoto University. The 1st EMSES was held in 2001 in Thailand and the symposium has been expanded in its scientific contents as well as the academic network. I believe that the 10th EMSES gives a good opportunity to all participants to exchange their knowledge and idea to realize eco-friendly energy system in society. I would like to express my welcome to all participants and sincere thanks to the 10th EMSES organizing committee and all supporting organizations to make us having this symposium. I hope that the symposium will be successful and lead to further progress in energy science and technology and also in friendships of participants.

Professor Yukio Ogata, Ph.D.
Director of Institute of Advanced Energy, Kyoto University
I want to express my hearty welcome to all participants of Eco-Energy and Materials Science and Engineering Symposium (10th EMSES). This symposium is aiming the realization of importance of energy and materials technology through the academic, science and technology network among the world communities. The symposium gives an opportunity for researchers to discuss their research works and also to initially stimulate the development of research works on eco-energy and materials science and engineering. Once the cooperation among researchers has been created, the further cooperation work will be developed.

I would like also extend my sincere thanks to all who made the meeting possible, including the 10th EMSES organizers, the SEE forum committee members, and the Japanese Government, JSPS, for their kind support. I am looking forward to seeing you in Ubon Ratchathani, Thailand.

Professor Takeshi YAO, Ph.D.
Former Dean of Graduate School of Energy Science, Kyoto University
and Program Leader, Global COE “Energy Science in the Age of Global Warming”
Rajamangala University of Technology Thanyaburi (RMUTT), in conjunction with Kyoto University, is pleased to host the 10th Eco-Energy and Materials Science and Engineering Symposium (10th EMSES).

RMUTT has a major mission on encouraging and supporting all areas of research. One of the key reasons is to assist in developing capability in science and technology in order to cope with recent rapid change in this field. We have jointly set up an academic symposium on the 10th EMSES with the perception on the significance of exchanging knowledge and research experiences between researcher in the field of energy, materials technology and environmental science. This symposium is not only giving an opportunity for Thai and foreign researcher to present and discussion their research works and update their expertise but also to initially stimulate the development of research works on eco-energy and materials science and engineering. Once the cooperation among researchers has been created, the closer future cooperation incorporate with joint-research works will be developed. Thus, to support the aforesaid role, the symposium working committee would like to invite you to participate in this academic symposium.

I would like to express our sincere thanks to the organizing committee, participants and contributors for your kind corporation to this symposium. I wish this symposium proceeding will be a useful reference for future scientific research development.

Sommai PIVSA-ART, Ph.D.
Dean of Faculty of Engineering, RMUTT
Director of CoE on Sustainable Energy System (Thai-Japan)
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Scintillation Properties of Ce-doped YAP and Lu$_{0.3}$Y$_{0.7}$AP Single Crystals at 320 and 662 keV Gamma Rays

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Abstract—Scintillation properties of YAlO$_3$:Ce (YAP:Ce) and Lu$_{0.3}$Y$_{0.7}$AlO$_3$:Ce (Lu$_{0.3}$Y$_{0.7}$AP:Ce) single crystals were investigated for gamma ray energies at 320 and 662 keV. The light yield and energy resolution were measured with a Photonis XP5200B PMT. For 320 keV gamma rays ($^{57}$Co source), the YAP:Ce showed the light yield of 31,800 ph/MeV, which is much higher than that of 14,800 ph/MeV obtained for Lu$_{0.3}$Y$_{0.7}$AP:Ce. The energy resolution of 6.1% obtained with YAP:Ce is much better than that value of 11.1% obtained with Lu$_{0.3}$Y$_{0.7}$AP:Ce. For 662 keV gamma rays ($^{137}$Cs source), the YAP:Ce showed the light yield of 32,000 ph/MeV, which is much higher than that of 15,100 ph/MeV obtained for Lu$_{0.3}$Y$_{0.7}$AP:Ce. The energy resolution of 4.4% obtained with YAP:Ce is much better than that value of 9.2% obtained with Lu$_{0.3}$Y$_{0.7}$AP:Ce. Superior energy resolution for YAP:Ce is due to its much higher light yield and lower contribution of intrinsic resolution. The scintillation light loss of tested crystals at both gamma ray energies was also presented. The estimated photofraction was determined for both crystals and compared with the cross-sections ratio calculated using WinXCom program.

Keywords—gamma-ray detectors, Lu$_{0.3}$Y$_{0.7}$AP:Ce, scintillators, YAP:Ce

1. INTRODUCTION

The study of scintillation properties of inorganic scintillation crystal is important in many scientific, industrial and biological applications for their potential use in radiation physics, medical physics and dosimetry, industry, and radiation shielding. Scintillation materials play an important role in detection and spectroscopy of energetic photons. Important requirements for the scintillation crystals used in these applications include high light yield, fast response time, high stopping power, good energy resolution, good proportionality of the light yield, minimal afterglow, and low production costs. Good reviews on development of inorganic-scintillators and development of scintillation crystals for gamma ray spectrometry have been published by van Eijk[1], Moszynski[2], and recently by Lecq et al.[3].

In the last decade, there has been the introduction of several new scintillators for medical imaging, in particular cerium-doped crystals as YAP:Ce or LSO:Ce exhibit better luminescence and scintillation properties compared to the classical ones (BGO, NaI:Tl, CsI:Tl). During last years many efforts were devoted to the development of heavy scintillators based on cerium-doped crystals, especially, crystals of perovskite type (Lu$_x$Y$_{1-x}$AP:Ce) were developed for x = 0-1.

The aim of this work is to study scintillation properties for YAlO$_3$:Ce (YAP:Ce) and Lu$_{0.3}$Y$_{0.7}$AlO$_3$:Ce (Lu$_{0.3}$Y$_{0.7}$AP:Ce) single crystal scintillators at 320 and 662 keV gamma rays. The light yield and energy resolution for 320 and 662 keV gamma rays were measured using PMT readout and the intrinsic energy resolution of both crystals was calculated. The scintillation light loss of tested crystals at both gamma ray energies was presented. The estimated photofractions for both crystals were also determined and compared with the results with cross-sections ratio values, calculated using WinXCom program.

2. METHODOLOGY

Two cerium-doped scintillation crystals, YAP:Ce and Lu$_{0.3}$Y$_{0.7}$AP:Ce, with the size of 10x10x5 and 5x5x9 mm$^3$, respectively, were supplied by Crytur Ltd.(Czech republic).

Each crystal was optically coupled to a Photonis XP5200B photomultiplier tube (PMT) using silicone grease. The 320 and 662 keV gamma sources were positioned along the cylindrical axis of the scintillator and the PMT. The signal from the PMT anode was passed to a CANBERRA2005 preamplifier and was sent to a Tenelec TC244 spectroscopy amplifier. A shaping time constant of 4 μs was used with both crystals. The energy spectra were recorded using a Tukan PC-based multichannel analyzer (MCA)[4].

The photoelectron yield, expressed as a number of photoelectrons per MeV (pMeV), was measured by Bertolacini method [5,6]. In this method the number of photoelectrons is measured by comparing the position of a full energy peak of gamma ray detected in the crystals with that of the single photoelectron peak from the photodiode, which determines the gain of PMT.

3. RESULTS AND DISCUSSION

Energy Spectra and Light Yield

Fig. 1 presents a comparison of the energy spectra for 320 keV gamma rays from a $^{57}$Cr source measured with
YAP:Ce and Lu0.3Y0.7AP:Ce crystals. The energy resolution of 6.1% obtain for YAP:Ce is better than that of 11.1% for Lu0.3Y0.7AP:Ce. Note a higher photoation in the spectrum measured with Lu0.3Y0.7AP:Ce, as would be expected due to a higher effective atomic number \(Z_{\text{eff}}\) and density of the Lu0.3Y0.7AP:Ce crystal.

Table 1. Light Yield and Energy Resolution at 320 keV Gamma Rays for Both Crystals

<table>
<thead>
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<th>Lu0.3Y0.7AP:Ce</th>
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<tr>
<td>Photoelectron yield [phe/MeV]</td>
<td>8,430 ± 420</td>
<td>4,400 ± 220</td>
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<tr>
<td>Light yield [ph/MeV]</td>
<td>31,800 ± 3,200</td>
<td>14,800 ± 1,500</td>
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<tr>
<td>(\Delta E/E) [%]</td>
<td>6.1 ± 0.3</td>
<td>11.1 ± 0.6</td>
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</tbody>
</table>

Table 2 summarizes comparative measurements of photoelectron yield and energy resolution at 662 keV gamma rays for the tested crystals. The YAP:Ce showed a photoelectron yield of 8,480 phe/MeV. This value corresponds to about 32,000 ph/MeV at the QE of 26.5% for peak emission at 360 nm. The tested Lu0.3Y0.7AP:Ce showed the photoelectron yield of 4,500 phe/MeV. This value corresponds to about 15,100 ph/MeV at the QE of 29.8% for peak emission at 375 nm.

Table 2. Light Yield and Energy Resolution at 662 keV Gamma Rays for Both Crystals

<table>
<thead>
<tr>
<th>Crystal</th>
<th>YAP:Ce</th>
<th>Lu0.3Y0.7AP:Ce</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photoelectron yield [phe/MeV]</td>
<td>8,480 ± 420</td>
<td>4,500 ± 230</td>
</tr>
<tr>
<td>Light yield [ph/MeV]</td>
<td>32,000 ± 3,200</td>
<td>15,100 ± 1,500</td>
</tr>
<tr>
<td>(\Delta E/E) [%]</td>
<td>4.4 ± 0.2</td>
<td>9.2 ± 0.5</td>
</tr>
</tbody>
</table>

Note a significantly higher light yield of 32,000 ph/MeV for the test YAP:Ce crystal, by about 190% compared with a same sized sample in Ref [7].

Energy Resolution

The energy resolution \(\Delta E/E\) of a full energy peak measured with a scintillator coupled to a PMT can be written as [8]

\[
(\Delta E/E)^2 = (\delta_{\text{c}})^2 + (\delta_{\text{p}})^2 + (\delta_{\text{m}})^2,
\]

(1)

where \(\delta_{\text{c}}\) is the intrinsic resolution of the crystal, \(\delta_{\text{p}}\) is the transfer resolution and \(\delta_{\text{m}}\) is the statistical contribution of PMT to the resolution. The statistical uncertainty of the signal from the PMT can be described as

\[
\delta_{\text{m}} = 2.355 \times \frac{1}{\sqrt{N}} \times (1 + \epsilon)^{1/2},
\]

(2)

where \(N\) is the number of the photoelectrons and \(\epsilon\) is the variance of the electron multiplier gain, equal to 0.1 for an XP5200B PMT.

The transfer component depends on the quality of optical coupling of the crystal and PMT, homogeneity of quantum efficiency of the photocathode and efficiency of photoelectron collection at the first dynode. The transfer component is negligible compared to the other components of the energy resolution, particularly in the dedicated experiments [8].

The intrinsic resolution of a crystal is mainly associated with the non-proportional response of the scintillator [8,9] and many effects such as inhomogeneities in the
scintillator which can cause local variations in the scintillation light output and non-uniform reflectivity of the reflecting cover of the crystal.

Overall energy resolution and PMT resolution can be determined experimentally. If $\delta_i$ is negligible, intrinsic resolution $\delta_{ic}$ of a crystal can be written as follows

$$ (\delta_{ic})^2 = (\Delta E/E)^2 - (\delta_i)^2. \quad (3) $$

<table>
<thead>
<tr>
<th>Detector</th>
<th>YAP:Ce + XP5200B</th>
<th>Lu$<em>{0.3}$Y$</em>{0.7}$AP:Ce + XP5200B</th>
</tr>
</thead>
<tbody>
<tr>
<td>N [electrons]</td>
<td>2,700</td>
<td>1,410</td>
</tr>
<tr>
<td>$\Delta E/E$ [%]</td>
<td>6.1 $\pm$ 0.3</td>
<td>11.1 $\pm$ 0.6</td>
</tr>
<tr>
<td>$\delta_i$ [%]</td>
<td>4.7 $\pm$ 0.2</td>
<td>6.6 $\pm$ 0.3</td>
</tr>
<tr>
<td>$\delta_{ic}$ [%]</td>
<td>3.8 $\pm$ 0.2</td>
<td>9.0 $\pm$ 0.5</td>
</tr>
</tbody>
</table>

Table 3. Analysis of the 320 keV Energy Resolution for YAP:Ce and Lu$_{0.3}$Y$_{0.7}$AP:Ce Crystals.

<table>
<thead>
<tr>
<th>Detector</th>
<th>YAP:Ce + XP5200B</th>
<th>Lu$<em>{0.3}$Y$</em>{0.7}$AP:Ce + XP5200B</th>
</tr>
</thead>
<tbody>
<tr>
<td>N [electrons]</td>
<td>5,610</td>
<td>2,970</td>
</tr>
<tr>
<td>$\Delta E/E$ [%]</td>
<td>4.4 $\pm$ 0.2</td>
<td>9.2 $\pm$ 0.5</td>
</tr>
<tr>
<td>$\delta_i$ [%]</td>
<td>3.3 $\pm$ 0.2</td>
<td>4.5 $\pm$ 0.2</td>
</tr>
<tr>
<td>$\delta_{ic}$ [%]</td>
<td>2.9 $\pm$ 0.2</td>
<td>8.0 $\pm$ 0.4</td>
</tr>
</tbody>
</table>

Table 4. Analysis of the 662 keV Energy Resolution for YAP:Ce and Lu$_{0.3}$Y$_{0.7}$AP:Ce Crystals.

Table 3 and 4 show the energy resolution of the studied crystals in 320 and 662 keV gamma ray spectrometry, respectively, the contribution of various components to the overall energy resolution was analyzed for 320 and 662 keV photopeak. The second row gives $N$, the number of photoelectrons produced in the PMT. The third row gives $\Delta E/E$, the overall energy resolution at 320 and 662 keV photopeak. The PMT contribution ($\delta_i$) was calculated using (2). From the values of $\Delta E/E$ and $\delta_i$, the intrinsic resolution ($\delta_{ic}$) was calculated using Eq.3. The superior energy resolution of YAP:Ce in both gamma ray energies as compared to Lu$_{0.3}$Y$_{0.7}$AP:Ce is mainly due to a small contribution of both $\delta_i$ and $\delta_{ic}$, which seems to follow a high light output (almost a factor of two) and good proportionality of the light yield, [10], respectively, for YAP:Ce crystal.

**Scintillation Light Loss in Thick Crystals**

Dujardin et al.[11] observed scintillation light yield depend mostly on the crystal height (the higher the crystal, the lower the light yield), not on length or width. Therefore the most interesting conclusion of key importance for the model to be presented by Wojtowicz et al.[12]. They proposed a simple two-ray ("2R") model. The scintillation light yield $Y(h)$ of the crystal as a function of the height of the crystal can be expressed as

$$ Y(h) = Y_0[1-exp(-2\mu h)]/2\mu h, \quad (4) $$

where $h$ stands for the height of the crystal, $\mu$ is the loss parameter (including absorption and scattering), and $Y_0$ represents the intrinsic yield which would be observed in the absence of scintillation light loss inside the material by optical absorption and photon scattering.

The points in Fig. 3 and 4 represent scintillation light yields of all tested crystals measured horizontally and vertically. Solid curves have been calculated from the two-ray formula (Eq.4).

**Fig.3. Scintillation Light Yield versus Height of the Samples at 320 keV Gamma Ray Energy**

**Fig.4. Scintillation Light Yield versus Height of the Samples at 662 keV Gamma Ray Energy**

Table 5. Intrinsic Yield, Loss Parameter and Energy Resolution at 320 keV Gamma Rays for Tested Crystals.

<table>
<thead>
<tr>
<th>Crystal</th>
<th>$Y_0$ [phe/MeV]</th>
<th>$\mu$ [cm$^{-1}$]</th>
<th>$\Delta E/E$ [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>YAP:Ce</td>
<td>8,670 $\pm$ 860</td>
<td>0.27 $\pm$ 0.03</td>
<td>6.1 $\pm$ 0.3</td>
</tr>
<tr>
<td>Lu$<em>{0.3}$Y$</em>{0.7}$AP:Ce</td>
<td>4,730 $\pm$ 470</td>
<td>0.30 $\pm$ 0.03</td>
<td>11.1 $\pm$ 0.6</td>
</tr>
</tbody>
</table>

Table 6. Intrinsic Yield, Loss Parameter and Energy Resolution at 662 keV Gamma Rays for Tested Crystals.

<table>
<thead>
<tr>
<th>Crystal</th>
<th>$Y_0$ [phe/MeV]</th>
<th>$\mu$ [cm$^{-1}$]</th>
<th>$\Delta E/E$ [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>YAP:Ce</td>
<td>8,680 $\pm$ 870</td>
<td>0.26 $\pm$ 0.03</td>
<td>4.4 $\pm$ 0.2</td>
</tr>
<tr>
<td>Lu$<em>{0.3}$Y$</em>{0.7}$AP:Ce</td>
<td>4,840 $\pm$ 480</td>
<td>0.32 $\pm$ 0.03</td>
<td>9.2 $\pm$ 0.5</td>
</tr>
</tbody>
</table>
Table 5 summarizes comparative measurements of the intrinsic yield, loss parameter and energy resolution at 320 keV gamma rays for the tested crystals. The intrinsic yield and loss parameter (8.570 phe/MeV, 0.27 cm⁻¹) obtained for YAP:Ce are better than the values (4.730 phe/MeV, 0.3 cm⁻¹) measured for Lu₂₀.₆₇Y₂₀.₃₇AP:Ce. Table 6 shows comparative measurements of μₐ, μ and ΔE/E at 662 keV gamma rays for both crystals. The intrinsic yield and loss parameter (8.680 phe/MeV, 0.26 cm⁻¹) obtained for YAP:Ce are better than the values (4840 phe/MeV, 0.32 cm⁻¹) measured for Lu₂₀.₆₇Y₂₀.₃₇AP:Ce. However, this can not be directly compared because of the different shape and size of the samples. Nevertheless, the higher intrinsic yield together with the small value of μ obtained for YAP:Ce and Lu₂₀.₆₇Y₂₀.₃₇AP:Ce seems to be promising.

Photofraction

The photofraction is defined here as the ratio of counts under the photopulse to the total counts of the spectrum as measured at a specific gamma ray energy. The photofraction for YAP:Ce and Lu₂₀.₆₇Y₂₀.₃₇AP:Ce at 320 and 662 keV gamma rays is collected in Table 7. For a comparison, the ratio of the cross-sections for the photoelectric effect to the total one calculated using WinXCom program [13] are given too. The data indicate that Lu₂₀.₆₇Y₂₀.₃₇AP:Ce shows much higher photofraction than YAP:Ce in a same trend with the cross-section ratio (σ-ratio) obtained from WinXCom program. The reason is due to much higher effective atomic number and density of the Lu₂₀.₆₇Y₂₀.₃₇AP:Ce crystal.

Table 7. Photofraction at 320 and 662 keV Gamma
Peak for YAP:Ce and Lu₂₀.₆₇Y₂₀.₃₇AP:Ce Crystals.

<table>
<thead>
<tr>
<th>Crystal</th>
<th>YAP:Ce</th>
<th>Lu₂₀.₆₇Y₂₀.₃₇AP:Ce</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (g/cm²)</td>
<td>5.4</td>
<td>6.2</td>
</tr>
<tr>
<td>Z_eff</td>
<td>34</td>
<td>53</td>
</tr>
<tr>
<td>Photofraction (%)</td>
<td>320 keV</td>
<td>18.1 ± 1.8</td>
</tr>
<tr>
<td></td>
<td>662 keV</td>
<td>5.3 ± 0.5</td>
</tr>
<tr>
<td>σ-ratio (%)</td>
<td>320 keV</td>
<td>11.5</td>
</tr>
<tr>
<td></td>
<td>662 keV</td>
<td>2.6</td>
</tr>
</tbody>
</table>

Note a much higher value of the photofraction compared with the cross-section ratio for the both studied crystals due to the thickness of the samples. It is the contribution of multiple Compton scattering to create a full energy peak.

4. CONCLUSION

In this work, interaction of 320 and 662 keV gamma rays with YAP:Ce and Lu₂₀.₆₇Y₂₀.₃₇AP:Ce crystals were studied. The energy resolution of YAP:Ce is superior than that of Lu₂₀.₆₇Y₂₀.₃₇AP:Ce due to a high light output and small contribution from its intrinsic resolution. Moreover, inhomogeneities of Ce-doped and some defects in the Lu₂₀.₆₇Y₂₀.₃₇AP:Ce crystal could affect the energy resolution, and the crystalline quality of this sample could be further improved. Lu₂₀.₆₇Y₂₀.₃₇AP:Ce showed much higher photofraction than YAP:Ce due to its much higher effective atomic number and density. Lu₂₀.₆₇Y₂₀.₃₇AP:Ce is suitable for high-energy gamma-ray detection. The experimental results of photofraction are in a same trend with the cross-section ratio obtained from WinXCom program.

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REFERENCES