CO12-1 Terahertz Absorption Spectra of Cholic Acid and its Sodium Salt

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INTRODUCTION: Various applications of terahertz (THz) electromagnetic waves have been reported in many fields, such as medical diagnosis, pharmaceutical analysis, and security enhancement. Absorption spectra in the THz range are very sensitive to differences in the crystal structure [1], and are applied to study the polymorphs of medicines [2]. THz spectra are also sensitive to the states of assembled molecules. In this study, we examined the characteristics and usefulness of coherent THz wave, and applied it to the analysis of bile acids, which are popular components of natural medicines.

EXPERIMENTS: Coherent THz wave was obtained from the transition radiation generated by L-band linear accelerator in Kyoto University Research Reactor Institute. The absorption spectra were measured as time-domain signal by the composite type liquid-helium-cooled silicon bolometers after through Martin-Puplett type interferometer and sample. By Fourier transforming the time-domain signal, the amplitude spectra were obtained [3]. Cholic acid and its sodium salt were used as samples.

RESULTS: Both powder and pellet forms of samples were used in this measurement. The size of pellets of both samples was 1 mm thickness containing 0.37 mmol of compound. A sample holder of 1 mm thickness was used in the measurement of powder sample. The spectra of cholic acid and its sodium salt (sodium cholate) are shown in Figs. 1 (A) and (B), respectively. In the pellet form, a possibility was found that cholic acid has a weak absorption band near 6 cm^{-1}. Moreover, the pellet form showed a better transmission than a powder form in the region from 11 to 24 cm^{-1}. One of the reasons of this phenomenon is considered as follows. In the process of forming a pellet, cholic acid powder was pressed. By the pressure, a change of assembly in the self-organized structure of cholic acid might have happened. It is plausible that this change of assembly was observed as the change of spectrum.

On the other hand, no significant difference between the spectra of the two forms of sodium cholate was observed. Because sodium cholate did not form the self-organized form, assembly of molecules was not much influenced by pressure in forming pellet, and no significant difference was observed in spectra.

By comparison between the spectra of cholic acid and sodium cholate, the weak absorption was observed in both pellet and powder form of sodium cholate at low wave number from 2 to 15 cm^{-1}. It should be clarified in future study where this weak absorption in low wave number comes from. These results were supported by XRD and THz time domain spectroscopy [4] (data not shown).

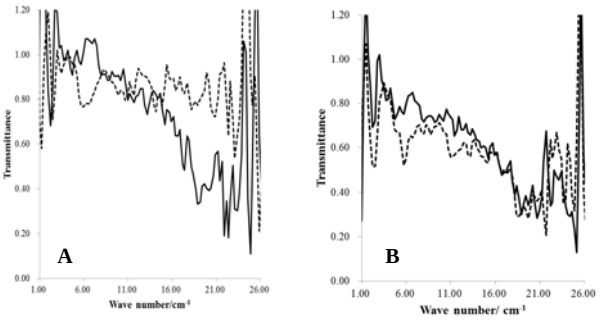

Fig. 1 Coherent THz spectra of cholic acid (A) and its sodium salt (B)
Solid line is spectrum of powder form sample, and dashed line is that of pellet form.

By using two kinds of THz wave sources, we can show a possibility of a change of assembly in the self-organized structure of cholic acid by pressure. The detail of the mechanism should be investigated by more measurement of THz spectrum, XRD and so on.

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採択課題番号 24001　テラヘルツ分光法による医薬品および医薬品原料の評価系の確立　共同通常
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CO12-2 A Brain Radiation Necrosis Model in Laboratory Animals

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INTRODUCTION: Since medical treatment apparatus progressed in recent years, the high dose radiotherapy to the brain tumor becomes possible, and, as a result, the prognosis of the brain tumor has improved. On the other hand, the brain radiation necrosis which arises during the long-term observation period after intensive radiotherapy becomes a serious problem. Although a part of molecular mechanism in a brain radiation necrosis was shown by our previous research, in order to prove these hypotheses strictly, it is necessary to create a brain radiation necrosis model in laboratory animals, and to analyze the pathology for each stage. Understanding the regulation mechanism of the cytokine in the brain radiation necrosis may have an important role in the treatment development.

EXPERIMENTS: Three 28-wk-old female Fisher rats with body weight 220 ± 5 grams were irradiated of 35 Gy to the right hemibrain with a single collimated (10 mm × 10 mm) ^{60}Co gamma-ray irradiator under anesthesia. Gamma-ray irradiation was applied using a ^{60}Co gamma-ray irradiator in the KUR. The irradiation method referred to the report of Wang et al., Li et al., and Nordal et al [1, 2, 3].

RESULTS: From 2011 to 2012, 47 rats were irradiated at KUR, which we had reported that there were no apparent histopathological abnormalities, at that time. But only one rat in the 35 Gy cohort was found to have abnormal signs of gait and movement from 26 weeks post-radiation. No gross neurologic abnormalities were observed in other rats. Standardized H&E staining was used to detect morphologic characteristics of brain tissue between 20 and 28 weeks after irradiation. There was apparent histopathological abnormalities in the brain, including white matter and blood vessel changes after all dose, as shown in Fig.1.
Newly irradiated 3 rats in the 35 Gy cohort had no apparent changes.

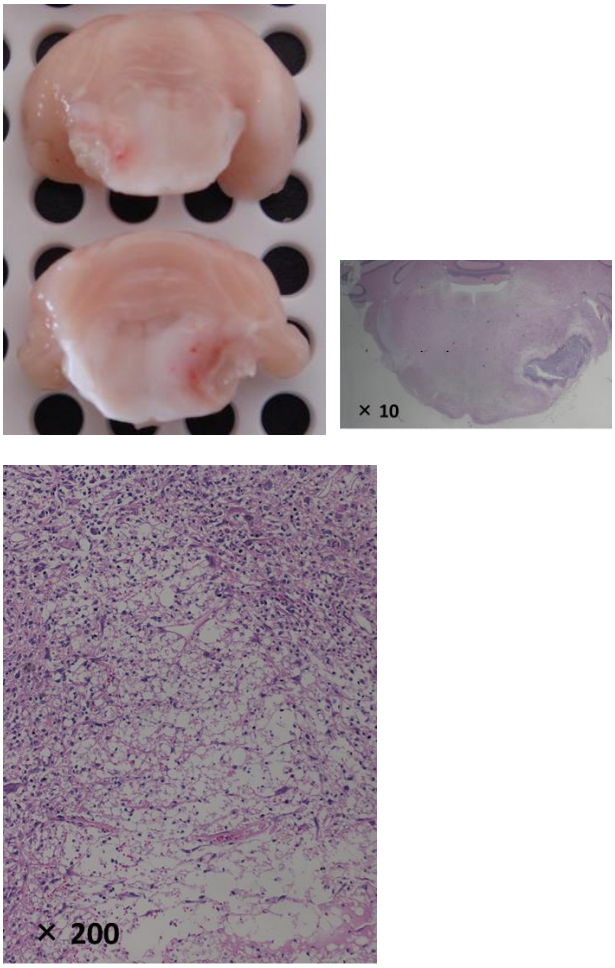

Fig. 1.
H&E staining in the specimen of the 35 Gy irradiated brain 28 weeks after irradiation. There were brain necrosis, micro bleeding, and interstitial edema. (Original magnifications, ×10, ×200)

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採択課題番号 24028　　放射線壊死の病態解明と新規治療法の研究　　共同通常
（大阪医科大学・脳）古瀬元雅、頼經英倫那、宮田とも、東保太一郎、宮武伸一、黒岩敏彦
（京大・原子炉）小野公二、増永慎一郎、田中浩基、近藤夏子

CO12-3 Radiation-Induced Luminescence for Applying to Retrospective Dosimetry

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INTRODUCTION: It is well known that quartz exposed to ionizing radiation emits afterglow (AG), radioluminescence (RL), thermoluminescence (TL) and optically stimulated luminescence (OSL). The luminescence phenomena have been used for retrospective dosimetry (e.g. [1, 2]). However, the reason for the emission mechanisms of their luminescences except for BTL [3] from Japanese natural quartz has not yet been well explained. In this study, the emission mechanisms of UVTL, RTL and OSL were investigated in conjunction with various radiation-induced phenomena after annealing treatments of quartz samples, involving TL, OSL and electron spin resonance (ESR) measurements. In addition to the luminescence mechanism investigation, as-received surface soils were irradiated by gamma-ray of ^{60}Co source which were collected at various places in Ibaraki prefecture. The irradiated samples were used in pulsed OSL (P-OSL) dosimetry test. The P-OSL can selectively extract OSL signals of quartz from various kinds of OSL signals emitted by minerals [4].

EXPERIMENTS: Coarse quartz grains (150~250 μm) were extracted by a general treatment of 6M hydrochloric acid (HCl) and 6M sodium hydroxide (NaOH) followed by concentrated hydrofluoric acid (HF) and sieving treatments. Further purification of the quartz grains was performed by hand selection for the sake of elimination of feldspar grains as low as possible under a microscope. The quartz samples were annealed at 500 and 800 ºC in an electric furnace. The annealed quartz samples were irradiated with ^{60}Co source at room temperature at Kyoto University Research Reactor Institute (KURRI). The irradiated samples were stored at room temperature for one day to eliminate afterglow effect in dark room. The ESR measurement was carried out using an ESR spectrometer (Jeol Ltd., JES-TE 200) at room temperature and −196 ºC, respectively. Prior to the ESR measurements, the quartz samples were annealed for 1 min at 50 ºC intervals ranging from 150 to 300 ºC as preheat treatment. After the ESR measurements, all luminescence measurements were performed for the quartz samples using a JREC automated TL/OSL-reader system installed with a small X-ray irradiator (Varian, VF-50J tube). All preparations were carried out under dim red light.

On the other hand, surface soils collected from Ibaraki were given a dose of 2 Gy by ^{60}Co source at room temperature. The irradiated soils were used in test of P-OSL dosimetry without quartz extraction.

RESULTS: As shown in the previous KURRI Progress Report, the ESR signals of Ti-centers ($[TiO_4/H^+]^0$, $[TiO_4/Li^+]^0$ and $[TiO_4/Na^+]^0$), Al-centers and RT-centers were detected in both quartz samples annealed at 500 and 800ºC. ESR signal intensities of Ti-centers and Al-centers were decreased with the preheat temperatures but ESR intensities of RT-centers were randomly changed with the temperatures.

UVTL and RTL glowcurves, and OSL decay curves were measured for all kinds of quartz samples. The UVTL and the RTL intensities were integrated in whole region of heating temperature. The OSL signal intensity was estimated by integrating the counts in the first 1 s of the decay curve after subtracting the average background estimated from the data in the last 2 s of the OSL curve. The intensities of the UVTL and the RTL decreased with increasing preheat temperatures. On the other hand, the intensities of OSL increased up to 250 ºC and then decreased to 300 ºC.

In this research, no clear correlation could be identified between luminescence intensity and ESR signal intensity. Therefore, further work is necessary to identify luminescence mechanism using ESR measurement and annealing experiment.

On the other hand, P-OSL measurement was applied to various kinds of surface soils to confirm that a known dose given in the KURRI could be accurately measured. However, some samples gave consistent results with the expected dose but the other samples did not. More P-OSL research should be required to develop the dosimetry using standard ^{60}Co source set in the KURRI.

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採択課題番号 24031　緊急時被ばく線量測定を目指した放射線誘起ルミネッセンスの基礎的研究　　共同通常
（原子力機構・核サ研）藤田博喜、（京大・原子炉）阪本雅昭、齋藤　毅

CO12-4 Thickness and Density of Adsorbed Additive layer onto Metal Surface under High Temperature and High Pressure Evaluated by TOF-Mode Neutron Reflectometry

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INTRODUCTION: Boundary lubrication is one of the most interesting topics in the field of tribology, and the recent development of physical and chemical analyzers has been accelerating to better understand the behavior of boundary lubrication films. Under the boundary lubrication, oiliness additives mixed in base oil are expected to form adsorption layers on a sliding surface and then achieve low friction and high durability. Previous reports have confirmed that the adsorptive performance of the additive to the surface greatly affects the friction coefficient of surface. However, physical properties of adsorbed layers are still unknown because of the substantial difficulty for *in-situ* analysis.

Our laboratory has proposed applying neutron reflectometry to directly measure physical properties, i.e., thickness and density, of adsorption layers formed by acid additives on metal surfaces [1,2]. We report the physical properties of adsorption layer and introduce our latest approach with the development of the TOF-mode neutron reflectometer for tribology use.

EXPERIMENTS: To widen applications of the neutron reflectometry to tribological studies, a TOF-mode neutron reflectometer was developed at the CN-3 in Kyoto University Research Reactor Institute (KURRI). A schematic diagram is shown in Figure 1. The carbonization nickel surfaces with various film thicknesses were deposited on ultra-flat silicon blocks by physical deposition. The obtained reflectivity profiles in air proved that the resolution of the developed reflectometer for film thickness was under 2 nm. This result proved that the reflectometry has high potential for use in advanced tribological studies on solid-liquid interfaces.

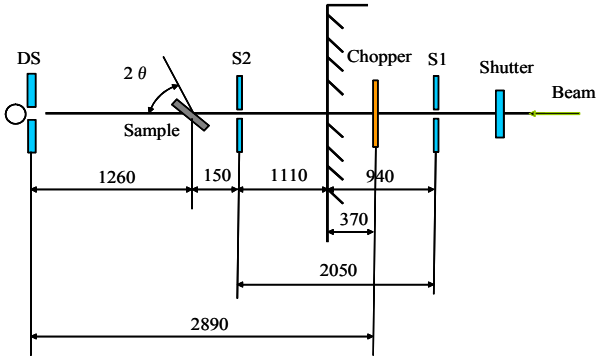

Fig. 1. Schematic diagram of reflectometer in KURRI

RESULTS: The carboxylic groups in the acetic acid in the lubricant were expected to preferentially adsorb to the metal surface and form a thin layer less than 10 nm thick. To examine the layer thickness and density using neutron reflectometry with the highest accuracy, we took the following procedure. First, we set the sample surface in the sample holder to obtain a neutron reflectivity profile from the interface between the sample surface and air. Second, the base oil poly-alpha-olefin (PAO) was poured into the sample holder and a reflectivity profile from between the surface and the PAO was similarly obtained. Finally, the additive was added into the PAO and mixed in the sample holder carefully and the reflectivity profile was again obtained. During the whole experiments, we didn't touch the neutron optics and the sample holder at all, and thus the difference in reflectivity profiles in each step were completely recognized as being provided by the existence of base oil and/or additive at the interface. After the above procedure, we checked the difference between the reflectivity profiles with theoretical fitting based on Parratt's theory. The amount of additive mixed into PAO was 0.1 mass%.

The obtained reflectivity profile is shown in Fig. 2. From the obtained reflectivity profiles, the thicknesses of the adsorption layer made by palmitic acid onto the copper surface were quite thin, about 1.4 nm. Interestingly, under hydrostatic pressure of 3 MPa, the thickness of adsorption layer increased to become about 5.9 nm. The results are summarized as follows.

(1) Formation of the adsorption layer was clearly observed when the undecanoic, palmitic and stearic acids were used as additives for each. Particularly, the adsorbed layers of these acids were expected to be monolayers.

(2) Hydrostatic pressure is possible to encourage to make the adsorbed layer to be a multilayer.

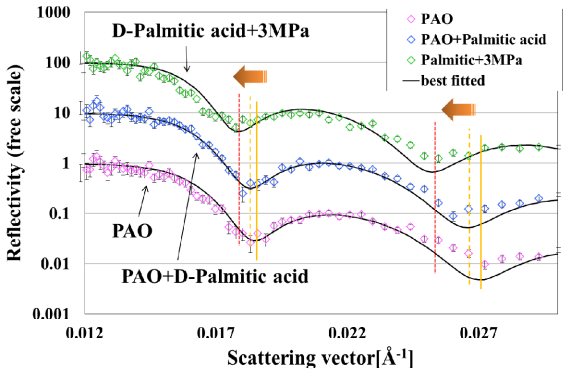

Fig. 2. Reflectivity profiles from copper surface

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採択課題番号 24035　　中性子反射率法による金属表面上添加剤吸着層の厚み・密度測定（温度・圧力依存特性の把握）　　共同通常

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（京大・原子炉）日野正裕、北口雅暁、小田達郎

CO12-5 Neutron Activation Analysis for Hafnium in Hafnium Oxide Films

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INTRODUCTION: Hafnium oxide (high-k) dielectric films are being introduced into silicon-based semiconductor devices in order to achieve higher electronic performance. The front-end processes require the thin dielectric films well-controlled in thickness for gate stacks. According to the international technology roadmap for semiconductors 2011[1], thickness of dielectric films should be controlled in 4 % process range. It becomes difficult to obtain the accurate thickness in length unit since the films are getting to be near atomic dimension and consist of complex structure like interface layers, which may involve atomic fluctuations. Reference materials whose properties are well-calibrated should shed light on quantification of the film thickness with small uncertainties. This study aims to quantify hafnium in thin hafnium oxide films by neutron activation analysis as quantitative method, and to develop reference materials applicable to semiconductor manufacture.

EXPERIMENTS: Hafnium oxide films were deposited on 4-inch Si wafers by magnetron sputtering method. In this study, the nominal thickness is 4 nm with homogeneity within 2 % in a wafer. Several wafers with hafnium oxide film were diced into 10 × 10 mm^2 pieces, and several pieces were picked-up for measurements.

Hafnium amounts were evaluated by INAA and calculated into area density. The surface area of a specimen was measured by taking images using a commercial optical scanner with a high resolution. From the images, the lengths of four sides of the chip were measured to calculate the surface area. Length calibration was performed by standard scales. For the production of standards to calibrate hafnium amounts, a natural standard solution was prepared by diluting SRM 3122 (commercially available from NIST) gravimetrically. In addition, a standard solution for internal standard was prepared by diluting JCSS antimony standard solution gravimetrically. Portions of the antimony solution were dropped from a polyethylene pipette onto pieces of the cleaned specimen, while portions of mixed solution (hafnium and antimony standards) were dropped onto cleaned filter papers. All specimens and standards were heat-sealed in individual clean poly-ethylene envelopes and stacked in a poly-ethylene irradiation container. The neutron irradiation was performed for 4 hours at 1 MW in research reactor KUR of Research Reactor Institute, Kyoto University. Gamma-ray activity of each specimen and standard was measured by a high-purity germanium detector (ORTEC) with an energy resolution around 1.8 keV FWHM at 1333 keV.

RESULTS: Figure 1 shows a gamma ray spectrum obtained from the specimen of hafnium oxide film with antimony internal standard solution. The peaks at around 482 keV from ^{181}Hf and 603 keV from ^{124}Sb were focused to determine hafnium amount in the oxide film. The counts in each peak were integrated for every specimen and standard, and then the intensities after the decay correction [2] were used to calculate relative intensities (^{181}Hf cps) / (^{124}Sb cps/ ng). The hafnium content in the specimen is estimated to be 3.5 μg from the calibration curve. Considering the surface area of the hafnium oxide film is 98 mm^2, the resulting hafnium content is 3.6 μg / cm^2.

Uncertainties of the quantification were evaluated from the sources as follows: gamma ray counting and the corrections, quantifying from the calibration curve, repeatability of the measurements, preparation of the standards, and isotope ratio. Total uncertainty of the quantification was estimated to be 0.92 % of relative standard uncertainty. Finally, certified reference material NMIJ-CRM 5605-a was developed using the results.

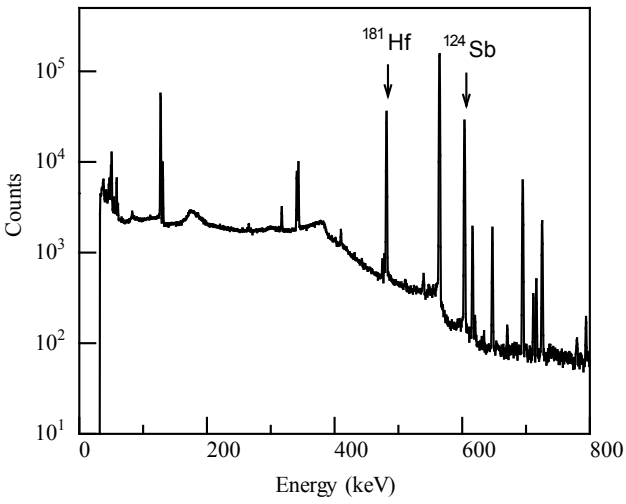

Fig. 1. Gamma ray spectrum from the hafnium oxide film with antimony standard solution.

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採択課題番号24044　中性子放射化分析によるハフニウム酸化膜中ハフニウムの定量　一般通常
（産総研・計測標準）高塚登志子、平田浩一、小林慶規

CO12-6 Mössbauer Microspectrometer for Geosciences

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INTRODUCTION: Fe^{2+}/Fe^{3+} ratio in minerals is an important geosciences' information, because the ratio suggests oxygen fugacities of the mineral formation, high or low temperature oxidation after crystallization, and weathering. Mössbauer spectroscopy is a major method to detect Fe^{2+} and Fe^{3+} in minerals without chemically decomposing analyses. Mössbauer spectroscopy is a recoilless atomic nuclear γ-ray resonance. Although Mössbauer spectroscopy is a very useful method, it was not applied to microspectroscopy. This is because there was no way to focus γ-ray. Recently, multi-capillary X-ray lense (MCX) to focus X-ray was developed and applied to Mössbauer microspectroscopy (Yoshida and Soejima, 2010). The author also started to construct Mössbauer microspectrometer using MCX for the applications to geosciences. In this report, we introduce newly developed Mössbauer microspectrometer and γ-ray beam examination. Although Mössbauer spectrum of Fe foil at 0.5mm was confirmed to be measured by this Mössbauer microspectrometer, the following problem remains. The γ-ray of 121 keV due to a transition from the second to the first excited states radiates from the γ-ray source ^{57}Co in addition to the 14.4 keV due to the transition from the first to the ground states. The 121 keV γ-ray straightly transmits the MCX and activates a sample at the focus of MCX and cause X-ray fluorescence. The X-ray fluorescence results in background of γ-ray spectra. To cut of the 121 keV as possible, a pinhole plate of Pb needs to be placed at the focus of MCX. S/N ratio can be improved by the Pb pinhole. However, Pb-L fluorescence of 10.6 keV is added to γ-ray spectra. The 10.6 keV Pb-L line is closed to 14.4 keV and makes S/N worse. To solve S/N problem, we are optimizing optical paths of γ-ray of this Mössbauer microspectrometer.

EXPERIMENTS and RESULTS: Figure1 shows a schematic figure of Mössbauer microspectrometer developed in this study. The γ-ray source is heavily surrounded by Pb shield to prevent 121keV from spreading. MCX and pin hole are set on micro-mechanical stage to adjust them to optimized positions. A laser is located behind a transducer to adjust mechanical center of MCX and pin hole before setting γ-ray source. Scanning pin hole of 0.5mmf, focusing point of g-ray by MCX was searched. At the optimized pin hole position, γ-ray intensity spectra and Mössbauer spectra of 57Fe enriched foil were measured. As a results, improved low background γ-ray intensity spectra and Mössbauer spectra with 6 peaks due to magnetic-splitting were confirmed.

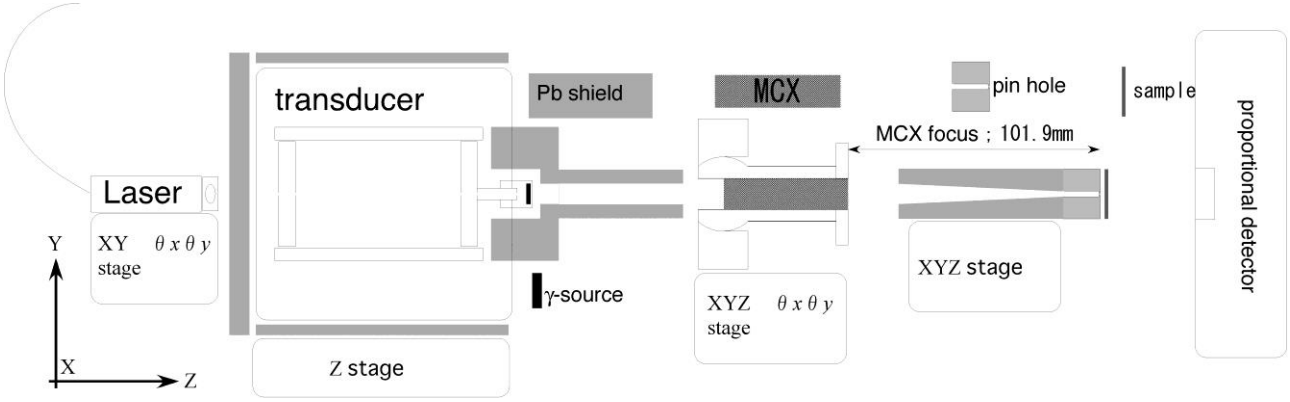

Fig.1 A schematic figure of Mössbauer microspectrometer developed in this study.

CO12-7 Precise Determination of Br in PP Resin Pellet by Instrumental Neutron Activation Analysis Using Internal Standardization

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INTRODUCTION: National Metrology Institute of Japan is responsible for developing certified reference materials (CRMs) and for establishing the traceability of SI (The International System of Units) on chemical metrology in Japan. To establish SI traceability, the primary method of measurements should be applied to the characterization of the CRMs. Recently, neutron activation analysis (NAA) using comparator standard is recognized as a potential primary ratio method [1]. Despite the potential of NAA as primary ratio method, the evaluation of the measurement uncertainty is required in any analysis. In general, there are three main components of uncertainty in NAA, that is, sample preparation uncertainty, neutron flux homogeneity, and gamma ray measurement uncertainty. Usually, flux monitor is used to correct the neutron flux in-homogeneity. However, although the flux monitor can correct the neutron flux variation using the count rate of the known amount of the monitor nuclide, it does not reflect the neutron flux of the actual sample. The most practical method to eliminate neutron flux in-homogeneity and to improve gamma ray measurement uncertainty is an internal standard method [2]. In this paper, we presented that notable capability of internal standardization in NAA for determination of Br in polypropylene (PP) resin pellet as a candidate CRM.

EXPERIMENTS: The PP resin pellet candidate CRM was produced by a mixing machine. The calibration solution of Br was prepared from NMIJ primary bromide standard solution. The Au solution for the internal standard was prepared from a high purity metal. The calibration solutions contained Br and Au. One hundred mg of the PP resin pellet samples was used for Br analysis. The Au solution was added to the samples before neutron irradiation. The neutron irradiations were performed by KUR (Kyoto University Research Reactor) PN-3(thermal neutron flux: 4.6 x 10^{12} $cm^{-2}s^{-1}$) for 10 min and TCPn (thermal neutron flux: 8.0 x 10^{10} $cm^{-2}s^{-1}$) for 30 min.

The γ ray measurement system consisted of a Canberra GC4070-7500 Ge detector and a Laboratory Equipment Corporation MCA600

.

RESULTS: It was found that the neutron flux varied according to the sample position in the irradiation capsule. The relative standard uncertainty of the in-homogeneity was estimated to be about 5.1 % by ^{198}Au sensitivity (cps/μg) at 411 keV of the internal standard (n=19). The uncertainty related to the neutron flux homogeneity significantly contributes to the overall uncertainty, if an internal standard is not applied. The calibration curve linearity was also improved by internal standardization. The calibration curves of ^{82}Br showed good and sufficient linearity. The relative uncertainty related to the calibration curve linearity was improved to 0.97 % from 2.0 % for ^{82}Br by using an internal standardization. The analytical results of Br by proposed method were in excellent agreement with the values obtained by Isotope dilution-Inductively Coupled Plasma Mass Spectrometry (ID-ICPMS). The relative expanded uncertainty (k=2) was 1.9 %, and it was comparable to that of ID-ICP-MS.

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採択課題番号 24048 内標準法を併用した中性子放射化分析法の高精度化に関する研究　共同通常（産総研・計測標準）三浦勉（京大・原子炉）奥村良、飯沼勇人、関本俊、高宮幸一

CO12-8 Development of Neutron Irradiation Field for Biological Research by Electron Linear Accelerator

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INTRODUCTION: Neutron beams have been used in many ways, for example, Boron Neutron Capture Therapy (BNCT) and neutron imaging. Nuclear reactor is a traditional neutron source and recently accelerators have been also utilized for it. There are still a lot of problems to be solved in order to use the neutron beam more effectively and safely. One of them is that we have to learn more about biological effects on humans and cells in terms of radiation protection because neutron is more effective than photon like gamma ray. The progress of biological effects research demands a new neutron source suitable for the study. This research intended to provide fundamental data to develop a neutron field suitable for biological research and focused on the distribution of neutrons and gamma rays from Ta target in measurement and simulation at KURRI-LINAC.

EXPERIMENTS: Three kinds of metal samples (Al, Ni, and Au) were set around the Ta target and irradiated with electron beam generated by KURRI-LINAC. The first irradiation was operated by 68.5 [uA] for 48.7 hours. The second one was done by 101.4 [uA] for 72.0 hours. Some nuclides in these samples were activated by gamma rays or neutrons from Ta target, whose activities were determined by Ge detector. It was thought the following reactions mainly occurred, ^{27}Al(n, a)^{24}Na, ^{58}Ni(n, p)^{58}Co, ^{197}Au(n, g)^{198}Au and ^{197}Al (g, n)^{196}Au. At the same time, simulation was done by Monte Carlo Code MCNP [1]. From the result and cross section data, production rate of the induced activities was calculated.

RESULTS: Fig. 1 to 3 showed the induced radioactivity measured in the experiments as well as calculated by the simulations. The horizontal axis and vertical one means the angle from electron beam [degree] and production rate [production/ (electron*atom)] respectively. In perspective of angular distribution, fast neutrons are emitted in the all directions from Ta target as well as thermal ones and gamma rays tend to be mainly done in forward direction. On the other hand, in terms of measurement and simulation, neutrons showed the same trend and value, especially fast neutrons. These results may suggest that the samples should be set in backward position where high neutron and low gamma dose rate are expected.

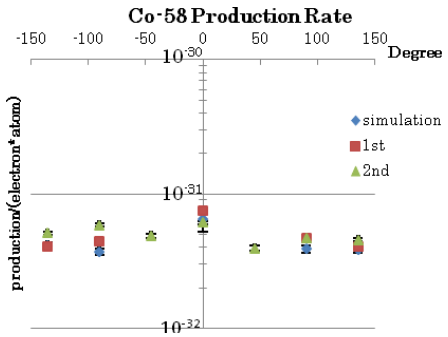

Fig. 1 Co-58 Production Rate

^{58}Ni (n, p) ^{58}Co reaction was trigger by fast neutron.

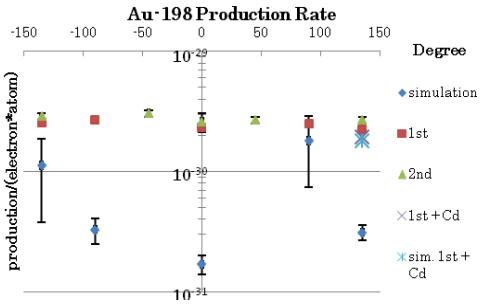

Fig. 2 Au-198 Production Rate

^{197}Au (n, g) ^{198}Au reaction was trigger by thermal neutron.

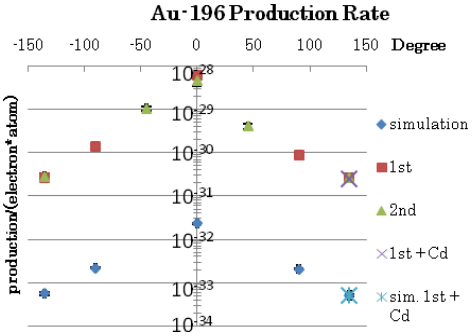

Fig. 3 Au-198 Production Rate

^{197}Au (g, n) ^{196}Au reaction was trigger by gamma ray.

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採択課題番号 24069　電子線形加速器を用いた生物影響研究用中性子照射場の開発　共同通常
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CO12-9 Determination of Nitrate Nitrogen Produced Through Photochemical Reaction Using Brucine Method

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INTRODUCTION: Nitrogen oxides and ozone are produced in the atmosphere by the irradiation effect of UV [1] and the former is dissolved into water to be nitric acid. Similar reactions happen in accelerator facilities and gamma irradiation facilities, and they would be damaged by corrosion.

A large amount of radioactive material was released into the environment by the Fukushima accident and has been emitting ionizing radiation. In order to estimate the production of NOx by these radioactive materials, in this report we produced nitrate nitrogen in the KUR-Linac and determined nitrated recovered in water with brucine method [2-3].

EXPERIMENTS: Nitrogen oxide was produced thorough irradiation of air by photon generated with Ta converter in the KURRI-Linac. The peak energy of accelerated electron was regulated 30 MeV (normal operation) and 9 MeV (low-energy operation). The produced nitrogen oxide in the target room was trapped into water (500 mL) as nitrate. The concentration of nitrate nitrogen was determined by absorbance (brucine method).

In this brucine method the absorbance of a mixture of 1mL of brucine solution, 2.5 mL of measurement sample, and 2.5 mL of 16 M H_2SO_4 was measured at a wavelength of 410 nm (high-purity water as reference). The sensitivity of this brucine method was investigated at the resulting concentration of brucine of 0.2 and 17.1 mg/mL.

RESULTS: The absorbance with brucine of 17.1 mg/mL in Fig. 1 shows that nitrate nitrogen of larger than 1ppm is detectable. In the case of the concentration of larger than 100ppm, however, this brucine concentration is too high to measure absorbance spectra. Fig. 2 shows the sensitivity of absorbance measurement by changing brucine concentration and the detectable concentration of nitrate raging from 1 to 1000ppm.

The concentration of nitrate trapped into water is shown in Fig. 3. Irradiation in normal operation yielded the detectable amount of nitrate; however, neither irradiation in low-energy operation nor irradiation energy less than 50 MJ yielded detectable results.

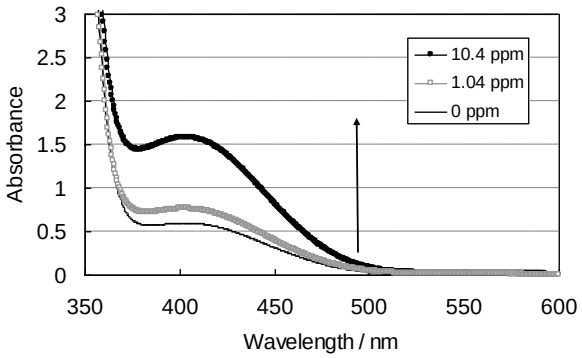

Fig. 1. The absorbance of nitrate nitrogen with brucine of 17.1 mg/mL

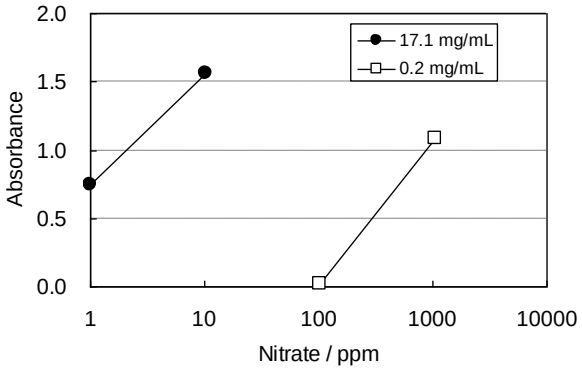

Fig. 2. Sensitivity of absorbance at 410 nm by changing brucine concentration from 0.2 to 17.1 mg/mL

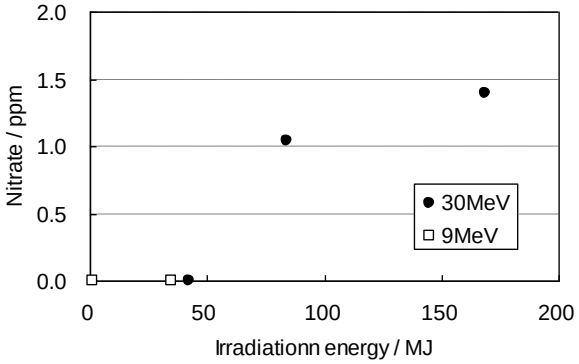

Fig. 3. Concentration of nitrate nitrogen trapped into water

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[3] R P.-Olmosa *et al.*, Talanta **53** (2001) 741-748.

CO12-10 Evaluation of Multiwire-Type Two-Dimensional Neutron Detector with Individual Line Readout

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INTRODUCTION: Some neutron scattering experiments performed using a high-intensity pulsed neutron source require two-dimensional neutron detectors that combine challenging performances such as an excellent spatial resolution, a high detection efficiency, and a high counting rate. With the objective of finding a neutron detector that satisfies these requirements, we are currently developing a two-dimensional position-sensitive neutron detection system that can read out individual signal line and consists of a multiwire-type detector element [1-2]. In the present study, we have performed irradiation test for the developed neutron detection system. This irradiated system was fabricated for J-PARC/MLF BL17 SHARAKU and this experiment was first irradiation test for the detector using a collimated neutron beam.

EXPERIMENTS: Neutron irradiation was carried our using a CN-3 cold neutron beam line at KUR. The irradiated neutron detection system consists of a 256 channel multiwire detector element (x: 128 lines, y: 128 lines) equipped into a pressure vessel, amplifier-shaper-discriminator (ASD) boards, optical signal transmission devices, position encoders with field-programmable gate arrays (FPGAs), and a fast data acquisition device. The pitches of each axis are 1 mm and the conversion gap is 20 mm. The charge signals collected by the detector element were amplified, shaped, and discriminated by ASD application-specific integrated circuits (ASICs). The nominal settings of the ASD-ASICs had an amplification factor of 3.1 V/pC and a decay time of 90 ns. Digital signals from the ASD-ASIC were transmitted to the position encoders via optical fibers as optical signals converted by specially-fabricated E/O-O/E converters.

RESULTS: An imaging experiment was performed to verify an operation of the position encoder. As an example of the experimental results, a measured two-dimensional image is shown in Fig. 1. In this experiment, 9 collimated neutron beams with a size of 0.7 x 1.0 mm^2, which was determined using a neutron imaging plate, was irradiated to the detector. It is confirmed that the position encoder works well and can be used in neutron detection system. The spatial resolution of our detector was less than 2 mm FWHM in both directions. Considering the Monte Carlo simulation results [1], this value appears to be reasonable. Fig. 2 shows the reactor power dependence to the measured counts of the developed detector system. The developed detector showed a linear response up to the full power, 5 MW, of KUR reactor and the counting rate at 5 MW was approximately 45 kcps. The linear response for counting rate greater than 45 kcps can be observed easily by irradiating with a higher flux of neutrons, because the counting rate of our system was not saturated.

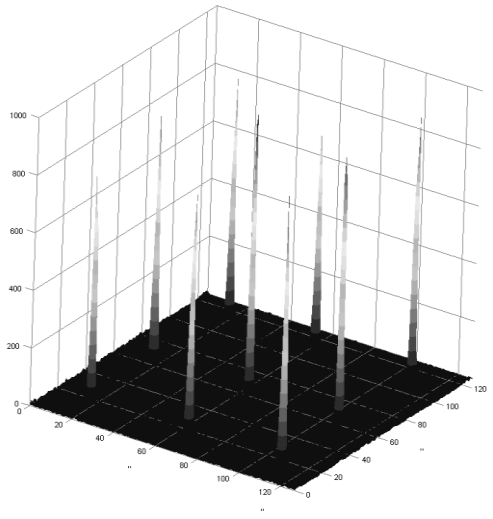

Fig. 1 Two-dimensional response obtained using a collimated beam with a size of 0.7 x 1.0 mm^2.

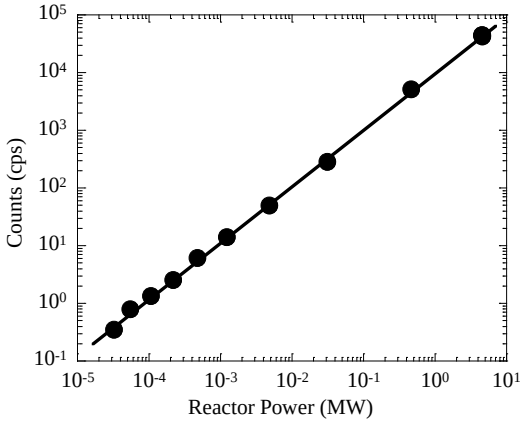

Fig. 2 Measured counts of developed system under neutron irradiation as a function of KUR reactor power.

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採択課題番号 24097　個別信号読み出し MWPC 二次元中性子検出器の特性評価　共同通常
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