Demonstration of Isotope CT Using NRF Absorption Method in UVSOR-BL1U

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Abstract:

By combining the Computed Tomography (CT) technique and Nuclear Resonance Fluorescence (NRF) absorption method (NRF-CT), an isotope specific CT image could be obtained. We have already obtained an isotope-specific CT image of ^{208}Pb in the CT target consisted of a natural lead rod, an iron rod, and vacancy in an aluminum cylinder shielded by an iron cylinder in the BL1U of UVSOR facility. To obtain a higher resolution image and to examine the capability of isotope identification, the CT target was changed to three lead rods with a natural lead, an enriched ^{208}Pb, and an enriched ^{206}Pb put into a bismuth cylinder. The NRF-CT image of ^{208}Pb obtained by the experiment will be discussed.

Keywords:

Nuclear resonance fluorescence (NRF), Computed Tomography (CT), Laser Compton Gamma-ray Beam, Isotope Distribution.

Summary:

By using NRF we can evaluate the quantity of the specific nuclide by measuring the scattered gamma-ray which has the excitation energy of the nuclide or the absorption of the incident gamma-ray. NRF has been studied for non-destructive diagnostics in industrial application, and the isotope imaging inside the spent nuclear fuel canisters and nuclear wastes [1]. Our previous study which carried out at the UVSOR-III electron storage ring has proposed a method to perform tomographic imaging of isotope ^{208}Pb distribution by NRF using LCS gamma-rays [2]. We measured a two-dimensional CT image of a lead isotope, ^{208}Pb, inside a sample of an aluminum cylinder including an iron rod, a lead rod, and a vacancy. The LCS gamma-ray beam with a flux of approximately 10^6 photons/s was provided by LCS of the 1.94-μm wavelength laser (5 W, CW) with 746-MeV energy electrons. The maximum energy of the LCS gamma-ray beam was 5403±16 keV. The diameter of the incident gamma-ray beam on the CT target was 8 mm, which was determined by the collimator located upstream of the BL-1U. To get a higher resolution CT image as well as a demonstration of separation between the isotopes, the lead collimator was changed to be 1 mm in diameter and the CT target was changed to be three cylindrical rods (enriched ^{206}Pb, enriched ^{208}Pb, and natural lead) implanted in a bismuth holder. Figure 1 shows the energy spectrum of the LCS gamma-ray beam measured by the HPGe detector. Two High Purity Germanium detectors were used to measuring the NRF gamma-rays scattered from the witness target (enriched ^{208}Pb). Plastic scintillation detector was used to measure the incident LCS gamma-ray beam flux, and a $LaBr_3$(Ce) detector was used to measure the flux of the transmitted gamma-ray beam. A new 1.896-μm fiber laser system (50 W, CW) has been installed to generate 5.52 MeV LCS gamma-ray beam with a total flux of 1×10^7 photon/s to excite a level with $J^\pi=1^-$ at 5.512 MeV in ^{208}Pb. The NRF-CT image reconstruction for the ^{208}Pb is under processing and its results and discussion in the image resolution and the acquiring time will be discussed.

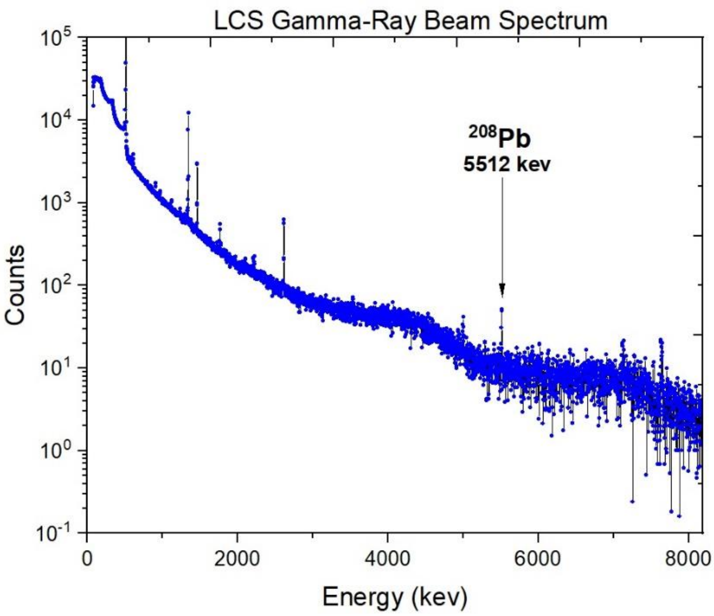

Figure 1 Typical NRF Spectrum from witness target

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