

Development and Status Quo of γ Spectrometer Based on Bromide

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Abstract

The brominated crystals (LaBr₃: Ce³⁺) activated by cerium ions are a new type of inorganic scintillator material that has been discovered in recent years because it has high energy resolution, fast attenuation time, etc. Nature has caused extensive attention in nuclear radiation detection in China. At present, the application of nuclear radiation detectors at home and abroad has developed rapidly. The research on LaBr₃ detector is mainly concentrated in the performance of detector performance, calibration, bromide crystals, etc., foreign research is mainly concentrated in the research Event radioactivity and its impact and elimination method. During the excellent performance of the LaBr₃ detector, it is basically avoided or simple to describe its essential radioactivity, but did not do too much in-depth study. This paper mainly introduces the research status of domestic and foreign research on the crystal in nuclear radiation detection and nuclear technology applications.

Keywords

LaBr₃: Ce³⁺; new type of inorganic scintillator material; Nuclear radiation detector; LaBr₃ detector.

1. Domestic Research Status of Bromide Crystals (LaBr₃: Ce³⁺)

1.1. Experimental Study on Growth, Performance and Packaging Technology of Bromide

In 2011, Xie Mizhen and Lin Li et al. [1] used in China University of Technology and Wuhan Photoelectric National Laboratory [1] with 18F radiation sources at normal temperature, using optical silicone fat to couple the LaBr₃: Ce³⁺ crystal to the photomultiplier, in digital manner Collect, and send the captured data into the PC for analysis, test the bottom radiation of the LaBr₃: Ce³⁺ crystal, and also test the energy resolution and time characteristics, 511 keV energy, LaBr₃: Ce³⁺ The energy resolution of the crystal is 3.6%, the attenuation time constant is 20ns, and the rise time is 3.4 ns, which confirms the excellent performance of the LaBr₃: Ce³⁺ crystals, indicating that it is relatively short to have a relatively short-term requirements for energy resolution requirements. Great potential of high performance γ energy spectrum.

In 2012, Kuangqiang and Zhang Chunsheng et al. [2] of Beijing Light Research Institute [2] use improved Bridgman declined to grow the diameter of 1.5 inch bromine (fluorine) crystals, i.e., blendina Crystal crystal (LBF), tested the wet-resistant X-ray excitation emission spectrum of the sample and the light output energy resolution attenuation time characteristics, etc. (Abbrevant, LBC, LB Crystals) Perform comparison, indicating that the flash of the LBF crystal is comparable to the LB crystal, and the moisture resistance is more resistant, and the emission spectrum is more deserved to detect photobire tube detection, and the practical performance is better, very good. A scintillation crystal having an application potential.

In 2012, Zhang Yan and Luo Ming, the Navy Protection Institute [3] using 1 "LaBr₃: Ce³⁺ crystal and GL-02KA type ESPEC high and low temperature-transformed moisture and heat laboratories to carry out bromide detector temperature experiments, and the temperature is

studied. The effects of change on the performance of bromide detector, the study shows that the energy resolution of the bromide detector does not exceed $\pm 5\%$ in the range of $-10^{\circ}\text{C} \sim 50^{\circ}\text{C}$, and the peak is not more than $\pm 6\%$. Will not affect the use of the detector, but the sub-site is significantly changed, and it is necessary to make a steady spectrum when the ambient temperature changes.

In 2015, Zou Ben, Guiqiang and Zhang Mingrong, Beijing Glass Research Institute [4] using ORTEC's energy spectrometer system to carry out the magazine flash crystal packaging technology experiment, studied the photocoupler of the reflective layer material and crystal surface morphology. $\phi 25.4\text{ mm} \times 25$. The effect of the scintillation light collection effect of 4 mm cylindrical crystal samples, the results show that the more effective optical coupling agent is an optical silicone gel of the refractive index 1.54, and the reflective layer material is polytetrafluoroethylene powder. The flashing crystal surface is a rough, lateral and outlet surface polishing.

1.2. Bromide, Iodide and Plastic Scintillation Detector Performance Comparative Experiment

In 2013, Xie Xi, Chengdu University of Technology, Lai Wanchang, Zhao Zulong, Wu Husi [5] using the IED-3000B digital energy spectrometer system, with Labr3 (CE) and Nai (TL) flash probe, in the same experimental environment Experimental study of energy resolution characteristics, analysis of performance indicators such as energy resolution, Labr3 detector's energy resolution of 662KEV rays of 137 cs can reach 2.8%, far better than Nai (TL) detector 6 % -7% resolution.

In 2014, Valley, Yan Wenqi, Liu Wenbin, and Zhang Gaolong [6] using 60CO and 137CS radiation and 90SR-90Y β radiation source for several commonly used scintillation detectors (bromide iodine) The signal characteristic energy resolution and time resolution of the sodium and plastic scintillation detector is measured, and these measurement results are compared. The results show that the plastic scintillation detector is suitable for the measurement of the time signal, the sodium iodide scintillation detector is suitable for energy measurement; the bromide scintillation detector is between the two, and can perform time measurement or energy measurement.

1.3. Research on the Practical Application of Bromide Detector

In 2010, Subaohua, Tsinghua University [7] using the Monte Carlo simulation method using bromide probes and other probes on seawater local gamma energy spectrum measurement. The results show that in the seawater gamma energy spectrum measurement, the traditional iodide detector has the lack of energy resolution. Compared with sodium iodide, the same size bromide detector has high detection efficiency and energy resolution; although high-purity germanium detector has the best energy resolution, it cannot be used for long periods of normal temperature; zinc Cadmium detection also has a good energy resolution, but since the current crystal volume is too small and the detection efficiency is too low. In terms of comprehensive energy resolution and detection efficiency, in the seawater gamma spectrum measurement, bromide is most desirable to replace the sodium iodide detector.

In 2012, Zhao Cuilan and Li Yong, a Chinese Academy of Sciences, and a Chinese Academy of Sciences, and Li Yongping et al. [8] use bromide Labr3 (CE) crystals to couple Japanese H8500 positional sensitive light-reducing pipes and burn-based The equilibrium charge distribution method of domain gravity method reads the circuit, and an imaging detection module is designed, and an output image of the imaging module is tested with a 99MTC ray source and a 57CO radiation source. The experimental results show that by selecting a suitable threshold, the response output area of the imaging module is about 40 mm, and the intrinsic resolution can reach 2 mm. The results of their findings indicate that the propomic gamma ray imaging

detection module can be developed by bromide LABR3 (CE) crystal mating position sensitive photofuminant tube and the local center of gravity.

In 2013, Zhang Wei, Dandong Oriental Measurement and Control Technology Co., Ltd., Liu Yongchao et al. [9] carried out the application of bromide detector in the performance improvement of neutron activation multi-element analyzer, using bromide detector to Multilan activation multi-element analyzer products, the neutron activation multi-element analyzer has made a new breakthrough in terms of elemental measurement accuracy and repetition.

2. Bromide Crystals (Labr3: Ce3 +) Abroad Research Status

2.1. Foreign Research in This Deduction Method

In terms of renewal peak, Canada's R.J.Tervo [10] designed computer handler according to the characteristics of statistical distribution law in 1983, making this deduction becomes efficient. .

In 1987, Clayton et al. Proposed a peak method. The peeling method is based on the rapid change in γ energy spectrum, and the count of a certain site is compared to the count of the adjacent sites. The advantage of the peeling method is to reduce the error brought by different mathematical models [11].

In 1988, Ryan was first proposed to use the SNIP method to deduct the γ energy spectrum. However, there are some defects, and the effect of different feature peaks use the fixed window width is not very ideal [12].

After that, Morhac et al. [13] uses high-order function filtering methods in 1997 to 2009 to improve the defects.

2.2. Foreign Experimental Study of Establishing Radioactivity of Bromide Detector

In terms of Labr3 (CE) detectors, the research work in foreign research work is relatively early, especially the energy spectrum interference caused by low energy regions.

In 2005, Bernabei et al. [14] Gran Satopo laboratory studied the effects of radioactive bits 138LA on γ energy spectrum measurements using lacl3 (CE) detectors, and determined 138LA through beta decay and EC by distributing fitting experiments. The specific effects caused by the 0 to 1.5 ME V energy zone on the gamma spectrum.

In the same year, JKHARTWELL et al. [15] The researchers use four LA CL3 (CE) scintillator detectors using four LACL3 (CE) scintillat detectors in the Idaho National Laboratory. It has shown that 138LA is indeed phenanthus. The end of the halide scintillator detector causes contamination, which may have a bad impact on the resolution of the type of detector.

In 2006, WJkernan et al. [16] studied the intrinsic radioactivity of isotope 138L by Labr3 (CE) detector. The HPGE detector was used in the natural environment and low bottom lead room, respectively. Labr3 (CE) crystals in the experiment. Performing the spectrum measurement, then analyzed 138LA in 1460KE V energy on 1460KE V energy, and also studied the self-energy scale of the intrinsic radioactivity of 138LA.

In 2007, Delft University's Fgaquarati, Ivkhodyuk et al. [17] using Labr3 detectors to study 138LA radioactive decay, they believe that Labr3 crystals are the most ideal research, because all energy released by β particles is deposited There is no energy loss inside the scintillation body in the dead layer. The paper is mainly to study the source and release of the low energy zone β particles, and the intrinsic radioactivity in the LABR3 detector is obtained by analyzing the analysis of the K, L layer of 138LA decay. Counts / (s, cm3) and consistent with the natural abundance of 138LA in theory.

In 2011, DOE Remote Sensing Laboratory DING YUAN, Paul GUSS et al. [18] proposed a Na I (TL) detector as a reference body, by obtaining Na I (TL) detector and LABR3 (CE) detection

The linear proportional relationship of the unit to calculate the substrate count caused by the Labr3 (CE) detector intrinsic radioactivity to the measurement line. Finally, the γ energy spectrum measured by the LABR3 (CE) detector and the ideal γ energy spectrum data obtained by reverse the use of Na I (TL) detector, and the intrinsic radioactive feature spectrum of the LABR3 (CE) detector is obtained.

3. Research Conclusions

In summary, the study of bromide crystals (LABR3: CE3 +) by domestic and foreign researchers can be seen that China has relatively mature for crystal growth, performance indicators, application technologies such as bromide crystals (LABR3: CE3 +). However, the analysis and measurement technology of its gamma spectrometer and the deduction method are also gaps abroad. Therefore, it is important for the analysis and measurement of bromide (Labr3: Ce3 +) γ spectrometer system and the research of this effect.

References

- [1] Xie Ming, Lin Li, Liu Shihao, Xiao Peng, Xie Qingguo. Performance assessment of blended bromide blistering crystals [A]. China Nuclear Association. China Nuclear Science and Technology Progress Report (Volume 2) - China Nuclear Association 2011 Annual Academic Annual Conference Papers Collection Seventh (Nuclear Power Technology and Nuclear Detection Technology Split, Pulse Power Technology and Its Application Split, Nuclear Change and Plasma Physical Split) [C]. Chinese Nuclear Association, 2011: 5.
- [2] Guqiang, Zhang Chunsheng, Zou Ben, Zhang Mingrong. Study on Growth and Properties of Bromine (Fluorine) Cerium () Crystal Crystal [A]. China Silicate Society Crystal Growth and Material Branch. The 16th National Crystal Growth and Materials Academic Conference Papers --04 Piezoelectric, Iron, Blinking and Other Functional Crystals [C]. China Silicate Society Crystal Growth and Material Branch: China Silicate Society, 2012: 1.
- [3] Zhang Yan, Luo Ming. Study on Temperature Characteristics of Bromide Detector [J]. Nuclear Electrical and Detection Technology, 2013,33 (02): 188-190.
- [4] Zou Benfei, Guiqiang, Zhang Mingrong. Study on the Packaging Technology of Blend Crutus Crycloo Crystal Crystal Crystal Crystal [J]. Journal of Artificial Crystals, 2016,45 (01): 64-68.
- [5] Xie Xicheng, Lai Wanchang, Zhao Zulong, Wu Hi Xi. Research and Comparison of Labr_3 (CE) and NAI (TL) Blinking Detector [J]. Nuclear Electrical and Detection Technology, 2014,34 (07): 917-920.
- [6] Gu Yawei, Yan Wenqi, Liu Wenbin, Zhang Gaolong. Reblock Properties of Bromide, Sodium iodide and Plastic Blinking Detector [J]. Laboratory Research and Exploration, 2015,34 (04): 64-67.
- [7] Su Zhihua. Technical Study on Savage Detectors of Seawater Non - Land [D]. Tsinghua University, 2010.
- [8] Zhao Cuilan, Chen Lihong, Li Yongping. Experimental study of bromide detector in gamma ray imaging [A]. China Nuclear Science Research Industry Application Branch, China Nuclear Physics Society, China Atomic Energy Science Research Institute Nuclear Technology Application Research The National Nuclear Technology Industrial Application Engineering Technology Research Center. The 3rd National Nuclear Technology and Applications Academic Seminar Meeting Information Document [C]. China Nuclear Science Research Industry Application Branch, China Nuclear Physics Society, China Atomic Energy Science Research Institute Technology Research Institute, National Nuclear Technology Industrial Application Engineering Technology Research Center: China Nuclear Physics, 2012: 1.
- [9] Zhang Wei, Liu Yongchao, Gong Yulin, Wei Xiaoyun, Xiao Xiandong. Application of Bromide Detector in Performance Improvement of Neutron Activated Multigen Analyzer [J]. Modern Mining, 2013,29 (12): 160-162.
- [10] Tervo R J , Kennett T J , Prestwich W V . An automated background estimation procedure for gamma ray spectra[J]. Nuclear Instruments & Methods in Physics Research, 1983, 216(1-2):205-218.

- [11] V A Solé, E Papillon, M Cotte et al. *Spectrochimica Acta Part B*, 2007, 62: 63.
- [12] Ryan C G, Clayton E, Griffin W L, et al. SNIP, a statistics-sensitive background treatment for the quantitative analysis of PIXE spectra in geoscience applications[J]. *Nucl. Instr. and Meth. B*, 1998, 34: 396-402.
- [13] Morhac M, Kliman J, Matousek V, et al. Background elimination methods from multidimensional gamma-ray spectra[J]. *Nuclear Instruments and methods in physics research A*, 1997, 401(1): 113-132.
- [14] Bernabei R, Belli P, F Montecchia, et al. Performances and potentialities of a LaCl₃:Ce scintillator[J]. *Nuclear Instruments & Methods in Physics Research*, 2005, 555(1/2): 270-281.
- [15] Hartwell J K, Gehrke R J. Observations on the background spectra of four LaCl₃:Ce scintillation detectors[J]. *Applied Radiation & Isotopes Including Data Instrumentation & Methods for Use in Agriculture Industry & Medicine*, 2005, 63(2): 223-228.
- [16] Kernan W J. Self-activity in lanthanum halides[J]. *IEEE Transactions on Nuclear Science*, 2006, 53(1): 395-400.
- [17] Khodyuk I V, Quarati F, Alekhin M S, et al. Luminescence Materials Research Group, Faculty of Applied Sciences, Delft University of Technology, Mekelweg 15, Delft, 2629 JB, The Netherlands.
- [18] D Yuan, Guss P, Mukhopadhyay S. Computational removal of lanthanum–cerium bromide self-activity[J]. *Nuclear Instruments & Methods in Physics Research*, 2011, 644(1): 33-39.