Influence of some factors on alpha energy spectrum of ^{241}Am fire alarm source

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Abstract Several primary factors influencing the alpha energy spectrum of ^{241}Am fire alarm source have been studied in order to get better alpha energy spectrum. The results show that the homogeneity and the thickness of metal surface coat and the size of active area of the source have considerable influence on the alpha energy spectrum of the source.
Keywords ^{241}Am fire alarm source, Alpha energy spectrum, Full width at half maximum

1 Introduction

^{241}Am fire alarm source is a kind of active source applied to an ion smoke-sensitivity fire alarm. The source is made up of stainless steel source shell and ^{241}Am source piece (majority of them are circular thin piece of ϕ 2~ 7 mm, a few of them are rectangle thin piece). Radioactive ^{241}Am is sandwiched between the surface cover coat (gold or gold-palladium alloy)[1] and the bottom layer (silver) by powder metallurgical technology. The thickness of surface cover coat is about 2~6 μm, the active layer is <1 μm and the bottom layer is 0.1~0.15 mm[2]. The energy of alpha particles from the source are generally small than 4.95 MeV, the FWHM of the alpha energy spectrums are wider (most of them are 0.47~1.36 MeV), moreover, the peak energys and the FWHM fluctuates in a range due to a metal cover coat.

The ^{241}Am source piece is cut out from the source belt. The source belt is made by rolling several times, and has the radioactivities from strong to weak. The energy of alpha particles from the source are lower if the source belt is rolled thick a little, conversely the energy of alpha particles are higher if the source belt is rolled thin little. But the source blet can not be too thin in order to prevent ^{241}Am from leaking. The reliability of the fire alarm will be influenced directly by the alpha energy spectrum of the ^{241}Am fire alarm source due to that the type of ion smoke-sensitivity fire alarm works depends on a big or a small change in the electric current produced in an ionization chamber of the detector by alpha particles, for this reason, the influence of some factors on alpha energy spectrum of ^{241}Am fire alarm source is studied to get a better alpha energy spectrum.

2 Equipment

The alpha energy spectrum instrument is consisted of alpha energy spectrum detector, vacuum system, amplifier, microcomputer, multichannel and data acquirement device. Fig.1 is the frame diagram of the spectrum measurement.

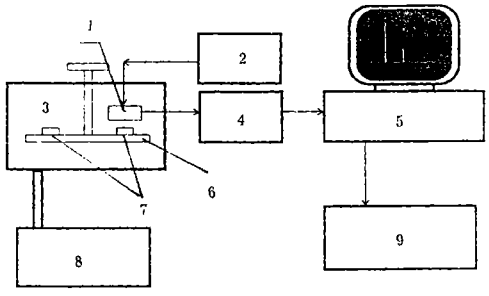

Fig.1 The frame figure of the alpha energy spectrum measurement
1 α detector and preamplifier, 2 High voltage supply, 3 Vacuum chamber, 4 Amplifier, 5 Multichannel and microcomputer, 6 Sample rack, 7 α sources waited to measure, 8 Vacuum pump, 9 Printer

The vacuum chamber can contain 16 sources with the diameter of less than 36 mm each time. The distance between the source and the detector can be adjusted from 0.2 to 70 mm. The detector is a semiconductor detector type GM8VR(N) made by Beijing 261 Factory, with a sensitive area of 8 mm in diameter. The

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FWHM of 5.48 MeV alpha energy spectrum of ^{241}Am alpha standard source is 17.4 keV when the bias is 150 V and shaping time is 1μs. Multichannel is a ACE-2K-W3 Plug-In MCA Cards made by ORTEC Company in U.S.A. A special software was used to analyse the alpha energy spectrum of ^{241}Am fire alarm source. This equipment was graduated with a mixed standard source of ^{241}Am, ^{238}Pu and ^{244}Cm three nuclides made by Amersham in England. A precision pulser type 8210 was made by Canberra in U.S.A, its linearity is better than 0.4% in 2~6 MeV energy range.

3 Results and discussion

3.1 The influence of the surface cover coat thickness of the source on alpha energy spectrum

As everyone knows, the energy of alpha from ^{241}Am fire alarm sources are not the same as the surface cover coat thickness are not the same. This influence can be determined by measuring and analysing the peak energy of alpha energy spectrums of the sources. Therefore, some sources with the same active area were measured and analysed under the same measurement condition. The data are listed in Table 1.

Table 1 Influence of the surface cover coat thickness of the source on alpha energy spectrum

Peak energy /MeV	Percent	FWHM /MeV	Percent	Peak energy /MeV	Percent	FWHM /MeV	Percent
(2.85~3.35)	(Samples 854)			(3.20~3.64)	(Samples 1160)		
< 2.85	0.5	0.60~0.70	0	<3.20	1.1	<0.60	0
2.85~2.95	9.6	0.71~0.80	0.2	3.20~3.30	3.2	0.60~0.70	0.1
2.96~3.05	22.2	0.81~0.90	13.7	3.31~3.40	19.7	0.71~0.80	9.9
3.06~3.15	26.5	0.91~1.00	25.5	3.41~3.50	31.3	0.81~0.90	26.1
3.16~3.25	25.8	1.01~1.10	37.8	3.51~3.60	35.1	0.91~1.00	27.9
3.26~3.35	14.3	1.11~1.20	19.7	3.61~3.64	9.4	1.01~1.10	35.2
>3.35	1.1	> 1.20	3.1	>3.64	0.2	>1.1	0.8
(3.80~4.20)	(Samples 560)			(4.35~4.85)	(Samples 3000)		
<3.80	0.5	<0.60	0.2	< 4.35	0	<0.50	0.2
3.80~3.90	12.1	0.60~0.70	18.5	4.35~4.45	3.0	0.50~0.60	9.3
3.91~4.00	32.3	0.71~0.80	48.9	4.46~4.55	21.2	0.61~0.70	30.6
4.01~4.10	36.7	0.81~0.90	32.0	4.56~4.65	47.5	0.71~0.80	59.3
4.11~4.20	18.4	>0.90	0.4	4.66~4.75	19.7	>0.80	0.6
>4.20	0			4.76~4.85	8.6		

Note: in the Table 1, four data are typical data of ^{241}Am fire alarm source; quality test according the energy range in common use of the ion smoke-sensitivity fire alarm. The numbers in the brackets below the peak energy are the peak energy range demanded. Percent is the probability of samples with a given ranges of peak energy or FWHM in the total measuring. The number in the another brackets are amount of samples measured

It is clear from the data in Table 1 that the lower the alpha peak energy is, the poorer the alpha energy spectrum is, and conversely last group of data in Table 1 make clear that the FWHM of the alpha energy spectrum is mainly 0.6~0.8 MeV if the alpha peak energy come up to 4.35~4.85 MeV.

3.2 The influence surface cover coat even character of the source on the alpha energy spectrum

Six source pieces with the length of 10 mm were randomly cut off from six representative source belts with the width of 8 mm. The source pieces were fixed on a platform which has an unit able to move the source piece along the ordinate or abscissa and the platform is in a vacuum chamber when the spectra were measured. The aperture of the light block of the detector is ϕ1 mm. The lengths of the source pieces were taken as an abscissa and the widths were taken as an ordinate. Beginning from 2 mm of the ordinate, one datum was measured every movement of 1 mm until the place of 6 mm. The experiment data are in Table 2.

Table 2 Influence of the source surface cover coat thickness even character on the alpha energy spectrum

Energy rang /MeV	Ordination measurement positions of the source pieces									
	2 mm		3 mm		4 mm		5 mm		6 mm	
	A/MeV	*B*/MeV	*A*/MeV	*B*/MeV	*A*/MeV	*B*/MeV	*A*/MeV	*B*/MeV	A/MeV	*B*/MeV
2.85~3.35	2.58	1.7	2.79	1.4	2.85	1.1	2.80	1.3	2.68	1.5
3.20~3.64	2.78	1.5	3.20	1.3	3.42	0.8	3.23	1.3	3.11	1.6
3.80~4.20	3.66	1.4	3.95	1.2	4.01	0.7	3.73	0.9	3.56	1.5
4.27~4.73	4.16	1.4	4.21	1.2	4.37	0.7	4.30	1.1	4.19	1.3
4.35~4.85	4.27	1.2	4.47	0.9	4.69	0.7	4.66	1.0	4.21	1.1
4.41~4.90	4.42	1.1	4.75	0.8	4.86	0.6	4.80	0.7	4.51	0.9

Note: in Table 2, the data in the first column are the energy range demanded. The alpha energy of the source belts are controlled according to the peak energy range of the alpha energy spectrum demanded when the source belts are made. *A* represents the peak energy, *B* represents FWHM

The data in Table 2 proved that the thickness of the surface cover coat of the active source is not even . The surface cover coats are thiner at the source belt middle along the length direction of the source belts, the even character and alpha energy spectra of them are good. At the width direction of the source belts, the farther it is away from the middle line along the length of the source belts, the thicker the surface cover coat of the sources are. The poorer the even character of them are, the poorer the alpha energy spectra are.

3.3 Influence of the source active area on the alpha energy spectrum

Six belts were taken when the experiment was made, one square source piece of 8 mm×8 mm of was cut off from every source belt randomly. Every source piece was fixed on a source rack in the vacuum chamber separately and the alpha energy spectra were measured using the different light blocks with the apertures of ϕ7, 6, 5, 3.2, and 2.4 mm, respectively. The data are in Table 3. It is not difficult to make out from the data in Table 3, the smaller the source piece is, the better the alpha energy spectrum of the source is.

Table 3 The influence of big or small active area of the source on the alpha energy spectrum

Light block apertures ϕ/mm	Source pieces/MeV											
	1		2		3		4		5		6	
	A	*B*	*A*	*B*	*A*	*B*	*A*	*B*	*A*	*B*	*A*	*B*
7.0	3.12	1.5	3.82	1.3	4.37	1.3	4.51	1.2	4.82	1.2	4.89	1.0
6.0	3.12	1.3	3.82	1.3	4.36	1.1	4.52	0.9	4.83	1.1	4.89	1.0
5.0	3.14	1.1	3.83	1.1	4.37	0.9	4.54	1.1	4.82	0.8	4.90	0.8
3.2	3.13	0.9	3.83	1.1	4.38	0.8	4.55	0.8	4.82	0.8	4.90	0.7
2.4	3.14	0.9	3.83	0.9	4.38	0.8	4.56	0.7	4.81	0.7	4.91	0.6

Note: *A* is the peak energy, *B* is FWHM

4 Conclusion

From the experiment data above, we can conclude that the surface cover coat thickess, the thickess even character and the active area of ^{241}Am fire alarm source may influence on the alpha energy spectrum; the FWHM of the α spectrum can come up to $\leq$0.8 MeV if the peak energy of the α energy spectrum of the source is >4.0 MeV (the surface cover coat of the source is thiner), the diameter of the active area of the source is $< \phi$5 mm, and the consistency of the α energy spectrum of the source is better.

References

1 FENG Gensheng, WANG Ying, FENG Xinzhan. Isotope, 1998, **11**(2):85

2 CHENG Jintai, CONG Huiling, YAO Chunbing *et al.* Isotope, 1998, **11**(2):7