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ARTICLE

Performance of Aluminium as Substitute for Be as Si (Li) Detector Window for Radioisotope Induced Energy Dispersive X-ray Florescence

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ABSTRACT

Generally, a thin Be (1-2 mil) is used as a window for Si (Li) detector used for X-ray spectroscopy. When Be undergoes wear and tear and ruptures it can be replaced by an aluminium window. In a case we have replaced a broken Be window with an Al window of thickness 450 μ and 15 mm diameter and have seen an excellent performance of the detector. Samples of biological significance (bacterial cells) and foils of double layer thickness were analyzed using the Am^{241} radioisotope source as excitation source and Al window detector and the elements were detected and seen well separated.

KEYWORDS

Aluminium, Be, Window, EDXRF, Si (Li) detector.

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INTRODUCTION

The mass absorption co-efficient of X-rays increases with the increase of Z [1]. Therefore for better efficiency, the window should be very thin of material whose Z is low as possible. Since Be is the lowest Z solid material with high resistivity it is generally selected as window for Si (Li) detectors for X-ray florescence spectroscopy [2]. However the high cost and its brittleness are the two main reasons to look for an alternative workable Si (Li) detector window. Aluminium is one such material which can be made thin (< 500 μ) to allow X-rays to pass and can also withstand vacuum conditions of the liquid N_2 (77 K) cooled Si (Li) detector [3]. A Si (Li) detector which has to be maintained at liquid N_2 temperature has to undergo thermal cycles to room temperature. Berrylium window is more susceptible to development of cracks and eventual sudden rupture. In such a case Al is good alternative, which has been demonstrated in this article.

EXPERIMENTAL

The detector purchased from Eurisys way back in 1990, had a beryllium window breakage due to which it had become non-functional. There were two possible solutions: (a) remove

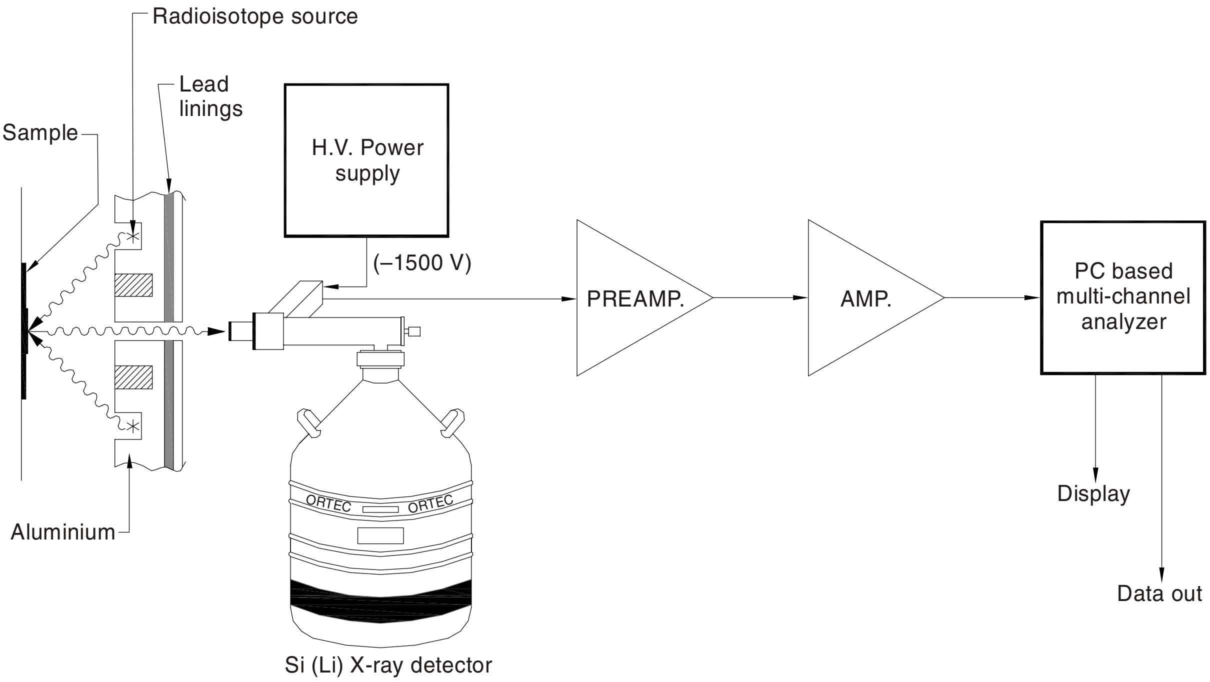

Fig. 1. Experimental set up for radioisotope induced EDXRF

the broken beryllium window and request the manufacturer (Eurisys) to supply a similar beryllium window or (b) replace the broken window with an equivalent aluminium window, such that the detector can be made operational in the least amount of down time. After a thorough inspection of the detector, it was decided that the broken beryllium window shall be replaced with an equivalent aluminium window. All other electronic devices such as FET, pre-amplifier, *etc.*, were tested and found to be in working condition. In order to replace the broken beryllium window an aluminum window with identical dimensions was fabricated. The inner surface was mirror polished to reduce thermal load on the Si (Li) crystal. Further, the front portion of the window was machined to < 0.3 mm thickness (300 μ) by high speed turning operations. After machining, the aluminium cover with the machined front window was fitted on the detector. A special vacuum pumping key (valve) was also fabricated. With the vacuum pumping key fitted to the pumping port of the detector, a thorough leak checking was performed with a helium based MSLD. The vacuum pumping key was fitted to the detector pumping port and the detector was pumped for several days leading to nearly ultrahigh vacuum conditions ($< 5 \times 10^{-6}$ mbar) in the detector. The detector was then baked for more than 24 h at a moderate temperature of 125 °C, during which time the pressure reached about 10^{-4} mbar. As the internal outgassing from the parts of the detector started reducing the pressure also started decreasing and reached its initial starting value of 10^{-6} mbar at which time the baking was turned off and the detector was allowed to reach room temperature. The detector was kept under vacuum pumping during the time it took to reach room temperature. The final pressure reading was well below 10^{-6} mbar at which point the vacuum pumping key was utilized for sealing off the detector.

The sealed off detector was then dipped in liquid N_2 for studying the detection sensitivity and resolution. A reverse bias of 800 V was applied across the semiconductor junction of Si (Li) detector and the resolution of the detector was 200 eV at 5.9 keV. Fig. 1 shows the experimental set up in which the detector was used.

The samples that run by the present set up were bacterial cells [4] and foils of Se deposited on Au. The samples were placed in front of XRF spectrometer (Fig. 1). For the excitation of samples, Am^{241} radioactive source (100 mCi) was employed in annular geometry to prevent the direct exposure of the excitation source to the detector and minimize backscatter interference [5]. The X-ray spectra were recorded for a counting time of 4000 s and stored in a PC based multi-channel analyzer for further offline analysis.

RESULTS AND DISCUSSION

Fig. 2 is the sample-source geometry. *Serratia marcescens* bacterial cells (4 mg) which show significant tolerance to uranium, Cs or Sr and bound appreciable amounts of all these metals were detected by ICP-MS. EDXRF was carried out to confirm the association of cesium and strontium with these cells. Fig. 3a is the spectrum of *Serratiamarcescens* bacterial cells with Cs binding and Fig. 3b is cells with Sr binding.

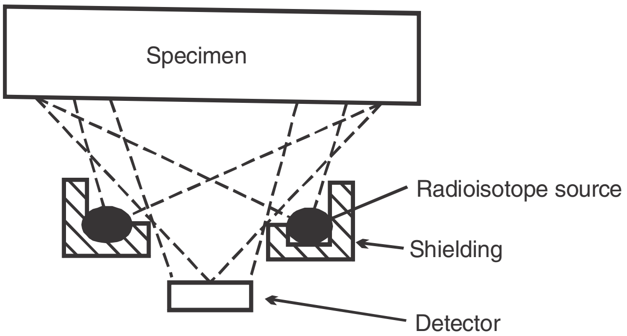

Fig. 2. Sample source (annular source) geometry

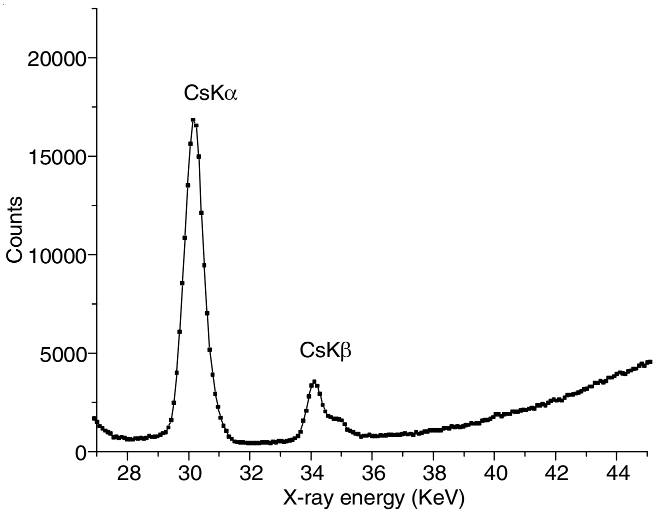

Fig. 3a. X-ray spectrum of Cs in cells

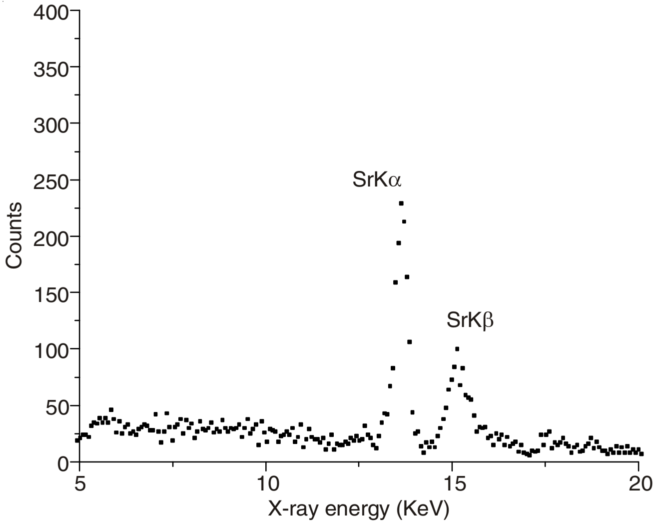

Fig. 3b. X-ray spectrum of Sr in cells

Fig. 4 is the spectrum of Se of 1.9 mg/cm^2 on Au backing of 4-5 mg/cm^2, while Fig. 5 shows the blank spectrum with no traces in background.

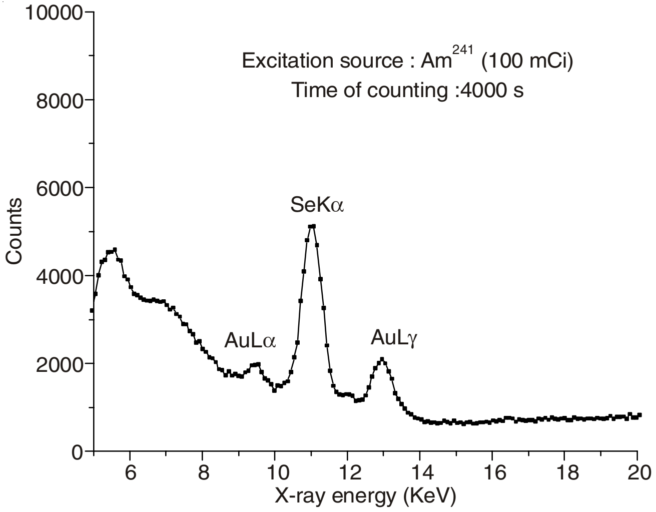

Fig. 4. X-ray spectrum of Se of 1.9 mg/cm^2 on Au backing of 4-5 mg/cm^2

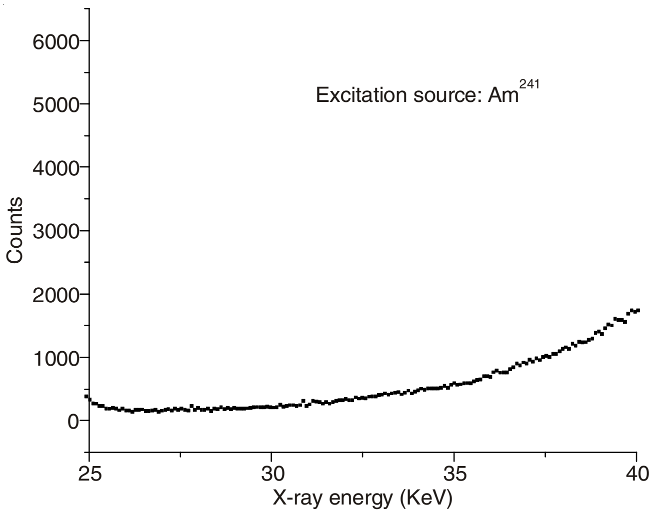

Fig. 5. X-ray spectrum of blank

All the spectra showed a clear spectrum and with no traces of background showing the good performance of aluminium window Si (Li) detector for X-ray spectroscopy [6].

Conclusion

Though there are a large numbers of new detectors available in the market for use in the field of X-ray spectroscopy such as SDD detectors and peltier cooled detectors. The liquid nitrogen filled Si (Li) detector have proven to be rugged, long lasting and efficient, except for the problem of Be window getting worn out, ruptured over time. This problem can be solved with a solution of replacing with aluminium window, which can be effectively used as an alternative to Be window for Si (Li) detector used for radioisotope induced energy dispersive X-ray spectroscopy.

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