

# A NEW ALPHA SPECTROMETRY FOR INFINITELY THICK SOURCES USING SI DETECTORS.

F.Shiraiashi, Y.Takami, T.Hashimoto, C.H.Mesquita\*  
M.M.Hamada\*, and M.H.O.Sampa\*

Institute for Atomic Energy, Rikkyo University, JAPAN  
\*Instituto de Pesquisas Energéticas e Nucleares, IPEN/CNEN-SP, BRAZIL.

## INTRODUCTION

In nuclear energy related facilities, contamination by transuranic nuclide must constantly be monitored.

As an example of the monitoring methods, thin electrodeposited sources prepared after the chemical separation processes, give high sensitivity in  $\alpha$  spectrometry by Si detectors or gridded ionization chambers; thus, often used for  $\alpha$  contamination analysis of environmental samples.

Because of the complicated source preparation processes, this method can hardly be recommended for analyzing many samples in a short period of time. For the cases of large area contamination, such as nuclear accidents, simple and rapid analysis is a prime importance.

As a simple  $\alpha$  detection method, so-called gross counting technique by ZnS scintillation counters, is well known. But this method does not give  $\alpha$  energy information at all and is insufficient to identify the nuclide. Consequently,  $\alpha$  background by natural nuclide cannot be subtracted from the measured gross counts.

And further, it is impossible to find the effective discrimination level for  $\alpha$  particle counting; therefore,  $\alpha$  counting efficiency for thick samples can only be determined by the actual measurement for the identical sample configuration and for the identical nuclide.

The purpose of this work is to develop a new  $\alpha$  spectrometry method for thick samples.

Experimental results and mathematical analysis have confirmed that qualitative analysis of  $\alpha$  nuclide in thick samples is feasible. And problems related to the analysis are also discussed in this report.

## EXPERIMENTAL METHODS

### Si Detectors

Si detectors used for experiments are Surface Barrier Detectors (SBD)–(1), fabricated from p-Si wafers. The vacuum evaporated Al face is the sensitive side for  $\alpha$  particle injection. With the Al face up, fine powdered samples were directly mounted on the electrode, so that the Al layer thickness is  $50 \mu\text{g}/\text{cm}^2$  which is thicker than usual detectors. Particles which contain a small amount of acid or alkali, such as ion exchange resins, often result leakage current increase. To prevent the degradation of detector characteristics, outer edges of the electrodes are covered by Epoxy Resin as shown in Fig.1.

### Measurements

$^{210}\text{Po}$  of 6 Bq/mg was adhered to fine Ni powder of several grain sizes. The powder was directly mounted on the Al electrode of an SBD and the  $\alpha$  spectrum was measured. Also measured in the same manner with another SBD, was the powder of low grade uranium ore. Another way of thick alpha sample spectroscopy is :a) filling

a sample dish, b)making the powder surface flat, c)placing an SBD close to the sample, and d)measuring the  $\alpha$  spectrum. However, if soil samples were measured by this method, Rn and Tn daughters stick to the electrode and their contamination give problems to the spectrum analysis(3).

It was confirmed that the powder samples adhered to Al electrodes could be removed almost completely by soft brushing and/or methanol cleansing.

$\alpha$  energy spectrum measured at the surface of an infinitely thick sample (thicker than  $\alpha$  ranges), in which  $\alpha$  emitters distribute uniformly and  $\alpha$  particle straggling is negligible, is given by the following formula(3);

$$dn(E)/dE = 0.25 \cdot S \cdot D / (dE/dx)_E \quad [1]$$

where  $dn(E)/dE$  [keV<sup>-1</sup>] : differential detector counts  
 $S$  [cm<sup>2</sup>] : detector sensitive area  
 $D$  [Bq/mg] : specific  $\alpha$  activity in the sample, and  
 $(dE/dx)_E$  [keV·mg<sup>-1</sup>·cm<sup>2</sup>] : stopping power of the medium at E

## EXPERIMENTAL RESULTS AND DISCUSSION

Fig.2 shows two groups of different spectra : 1)the measured  $\alpha$  spectra of <sup>210</sup>Po adhered to three different grain sizes of indefinitely thick Ni powder samples, and 2)the  $\alpha$  spectrum calculated by formula [1] with Ziegler's Stopping Power Data. In case the grain size is sufficiently smaller compared to  $\alpha$  range the measured spectrum agrees well with the calculated results. While grain size of the powder increases, alpha spectra peaking at the high energy edges tends to be significant. This tendency was unexceptionally observed in other metal powders. This peaking phenomena can be explained as followings: if grain size increases, the portion of  $\alpha$  particles which does not penetrate grain medium or go through short path to SBD, increase. Because all the  $\alpha$  emitters are adhered on the surface of grains comparative to or larger than the  $\alpha$  particle ranges. If noticeable peaking is observed with a sample, it means  $\alpha$  emitters are not distributed uniformly in it, and qualitative analysis by formula [1] can not be applied. It means some process has to be made. As shown in Fig.3 in the case of uranium ore, this can be easily solved by grinding the sample into fine powder in an agate mortar. Peaking is, however, advantageous to identify  $\alpha$  nuclide. This is especially true for the identification of artificial  $\alpha$  emitters, because they are, in most cases, attached on the surface of sand or ion exchange resin grains.

Total  $\alpha$  counting rate for infinitely thick samples, as calculated by integrating formula [1], is shown in Fig.4. Since the medium is SiO<sub>2</sub>, this result can be applied for soil samples as a good approximation.

## CONCLUSION

- (1)Without making any chemical separation process,  $\alpha$  spectrometry can be made by using a Si detector and infinitely thick samples.
- (2)Qualitative analysis for each nuclide can be made, if sample components are identified, by grinding samples into fine powder.
- (3)Edge peaking in an alpha spectrum can effectively used for the nuclide identification.

## References

1. F.Shiraishi, Y.Takami, and M.Hosoe, Nucl. Instr. & Meth., 226,107-111(1984).
2. Y.Takami, T.Hashimoto, F.Shiraishi, and K.Voss, IEEE Trans. Nucl. Sci., 33, 639 - 642(1986).

3. M.Hosoe, Y.Takami, F.Shiraishi, and K.Tomura, Nucl. Instr. & Meth., 223, 377-381(1984).
4. J.F.Ziegler, Helium stopping powers and ranges in all elemental matter (Pergamon, New York, 1977).

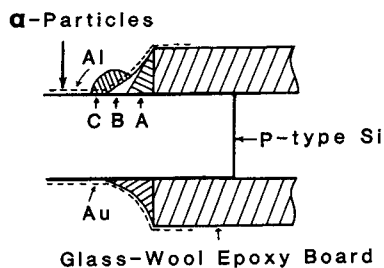


Fig.1

Cross-sectional view of Si detector.

A : Epoxy resin, with inorganic compounds

B : Epoxy resin, with amine type hardener

C : Epoxy resin, with polyamide hardener

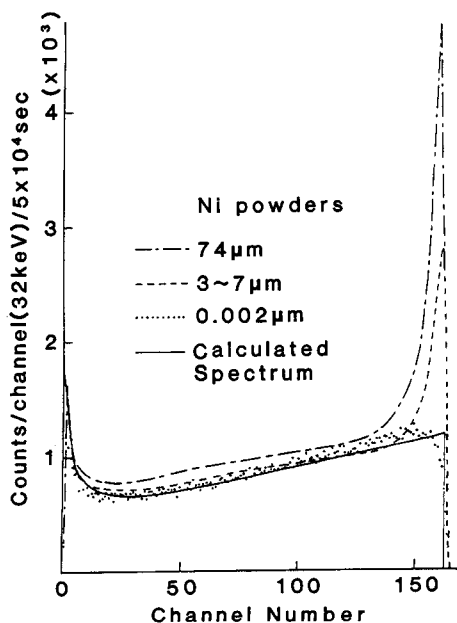


Fig.2

Three  $\alpha$  spectra of infinitely thick samples ( $^{210}\text{Po}$  was doped to fine Ni powder of three different grain sizes) and the  $\alpha$  spectrum calculated by Formula [1]

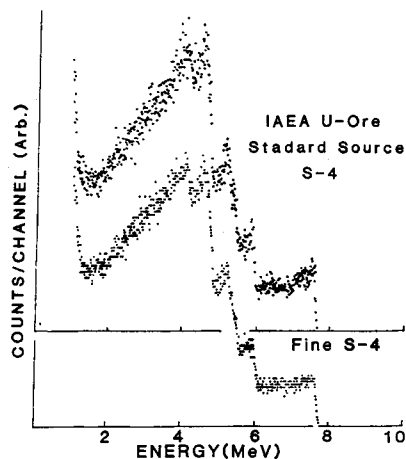


Fig.3

$\alpha$  spectrum of IAEA uranium ore (infinitely thick sample); the spectrum at the lower section is, of the finely crashed powder ore by an agate mortar.

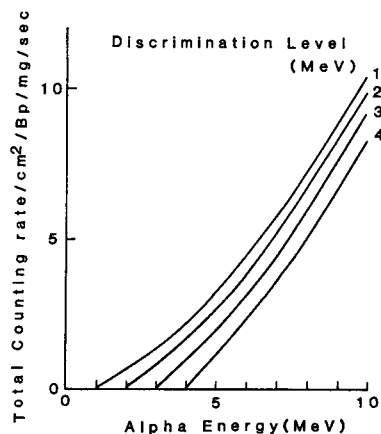


Fig.4

Total counting rate of  $\alpha$  particles by integrating Formula [1], assuming  $\text{SiO}_2$  as the medium. Detector area :  $1 \text{ cm}^2$   
Specific  $\alpha$  activity :  $1 \text{ Bq/mg}$   
Numerical figures on curves indicate the lower energy limit of the integration.