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FAST NEUTRON SPECTROMETER BASED ON CR-39 PROTON SENSITIVE TRACK DETECTOR

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A home-made proton-sensitive CR-39 nuclear track detector has been developed in our institute. Using this detector and the n-p scattering process the performance of a fast neutron spectrometer has been studied by applying two different methods. These methods are based on track density determinations by using varying radiator thicknesses or varying etching periods, respectively. A computer programme has been developed for calculating the neutron sensitivity as a function of neutron energy for the case of the two methods studied. In these calculations the conditions for the proton track development determined by the etch- track kinetics have been taken into consideration.

For both methods we have carried out investigations to measure the neutron sensitivities in terms of etch-proton tracks/neutron for 3.3 and 14.7 MeV neutrons. The sensitivities have been studied as a function of both the radiator thickness and the layer thickness removal.

Introduction

Recently a few works have been published about the development of fast neutron spectroscopy based on proton sensitive CR-39 nuclear track detectors [1, 2, 3, 4]. In these works the energy spectrum of neutrons is proposed to be determined either from the measured proton track density at varying PE radiator thickness, or from the minor axis of the observed proton tracks.

In the present work two methods are considered for performing neutron spectrometry. The first one is based on the use of varying etching time at fixed radiator thickness, the other one applies varying radiator thicknesses at a fixed etching time. We have performed some theoretical calculations and measurements to make clear certain behaviour of fast neutron spectrometer of that type. In the determination of the observable proton track density, the etch-track kinetics [5] is also taken into account.

Theoretical considerations

A schematic drawing of the methods proposed is shown in Fig. 1. If the neutron spectrum is divided into m intervals, the observed density of proton tracks, ρ, at a radiator thickness d and layer thickness removal h, is given by the relation

$$\rho = \sum_{i=1}^{m} S_i(E,d,h)\cdot\phi_i(E)$$

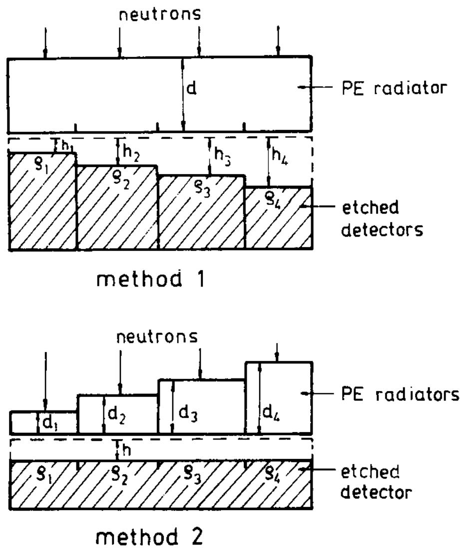

Fig.1. Schematical drawing to illustrate the principle of the neutron spectrometric methods studied. (d=radiator thickness, h= layer thickness removal, ϱ =density of etched tracks of scattered protons

where S_i is the neutron sensitivity, i.e. the number of observable tracks produced by one neutron in the energy interval i, and $\Phi_i(E)$ is the fractional fluence of neutrons in this interval. The values of S_i may be obtained from theoretical calculations, too.

For the calculation of S_i a computer programme was written taking into consideration the energy distribution on the detector surface of protons scattered in the radiator at different angles and in different depths. The minor axis and the projected length of the etched tracks were calculated from the relations of track etch kinetics. Our computer programme considers the proton tracks countable only if their minor axis and the projectd length simultaneously exceed 1 μm.

Results calculated for the first and the second methods are presented in Figs 2-3. From the results it is obvious that the first method is not sensitive enough for spectroscopic purposes above 10 MeV neutron energy, and by using the second method the neutron spectroscopy can be performed with a resonable resolution only above 5 MeV neutron energy.

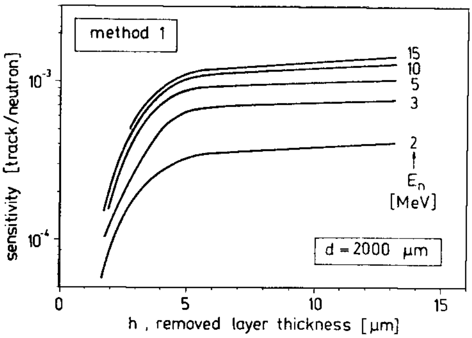

Fig.2. Neutron sensitivity calculated as a function of the layer thickness removal at different neutron energies

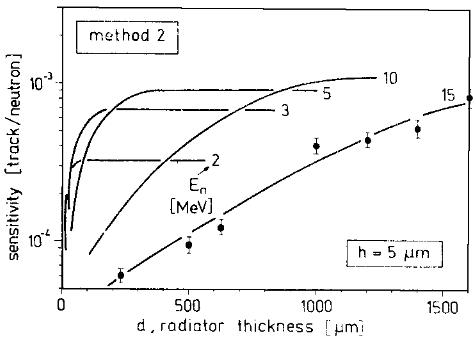

Fig.3. Calculated and measured neutron sensitivities as a function of of radiator thickness at various neutron energies

Experimental results

To check the calculated sensitivities measurements have been carried out with 14.7 and 3.3 MeV monoenergetic neutrons by using MA-ND/p type CR-39 track detectors. The proton tracks are etched in 20% NaOH at 70^{0}C and counted by projection microscope at 500 X magnification.

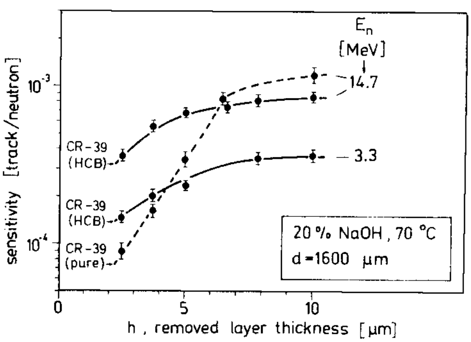

Fig. 4. Neutron sensitivity measured as a function of layer thickness removal at two neutron energies

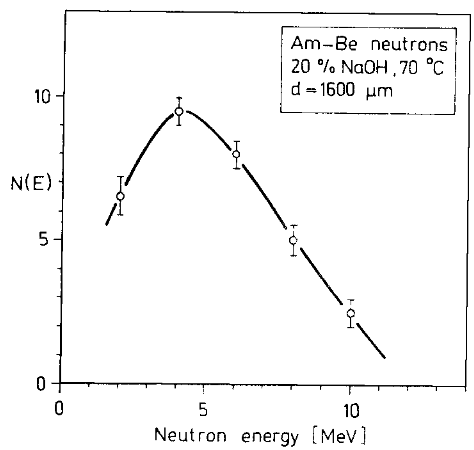

Fig.5. Measured neutron spectrum of an Am-Be source (first method)

Experimental results obtained by using the first method are shown in Fig. 4 and by using the second method they are given in Fig. 3. It can be seen that the measured data are in good agreement with the theoretical calculations. From the results it is obvious that the first method is applicable only up to 5-6 μm removed layer thickness.

We have tried to apply the first method measuring the neutron spectrum of an Am-Be source. The results obtained are given in Fig. 5.

Summary

From the theoretical and experimental results it can be concluded that the neutron spectroscopy seems to be realizable with an energy resolution better than 1 MeV only with the combined application of the two methods.

References

1. J.L. Decossas, J.C. Vareille, J.P. Moliton, J.L. Teyssier Theoretical study and calculation of the response of neutron dosemeter based on track detection, Rad. Prot. Dos., 5, 163-170.
2. S. Faermann, Y. Eisen, T. Schlesinger, E. Ovadia, A. Kushilevski, Spectroscopy and dosimetry of fast neutrons in the energy range (0.5-15) MeV using CR-39, 10th DOE Workshop, 1983.
3. A.P. Fews, T. Portwood, D.L. Henshaw, T.W. Turner, A. Worley, A CR-39 neutron spectrometer with application in 10 uSv dosimetry, 5th Symp. on Neutron Dosimetry, Neuherberg, 1984.
4. T.W. Turner, D.L. Henshaw and S.P. Fews, A CR-39 neutron spectrometer of sensitivity 1 mREM in the energy range 100 keV - 20 MeV with personal dosimetry applications, Nucl. Tracks, 8, 341, 1984.
5. G. Somogyi, I. Hunyadi, A.F. Hafez and G. Espinosa, A new possibility for high-resolution spectroscopy of nuclear particles entering CR-39 at selected dip angles, Nucl. Tracks, 8, 163, 1984.