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HEAVY ION RANGES IN GLASS DETECTORS

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ABSTRACT

Glass detectors, viz. sodalime, phosphate and quartz, were irradiated at GSI heavy ion facility at Darmstadt, Germany and at heavy ion Cyclotron facility at JINR, Dubna, USSR using ^{238}U(5.9 and 15.0 MeV/u), ^{131}Xe (5.9,11.56 and 14.5 MeV/u), ^{197}Au (11.4,11.67 and 15.95 MeV/u), ^{56}Fe (4.0 MeV/u) and ^{48}Ti(4.0 MeV/u) beams.Heavy ion ranges are measured in glass detectors using appropriate conditions. The calibration curves are obtained for all these glass detectors using different ion beams. The present study may be used for particle identification.

KEYWORDS

Glass, Radiation Damage, Range, Detector, Heavy Ion.

INTRODUCTION

Solid State Nuclear Track Detectors (SSNTDs) have found several applications in a wide variety of fields (Fleischer et al.,1975; Fischer and Spohr,1983) . Apart from several other applications of SSNTDs, Saxena et al. (1985) observed that a few sensitive detectors are quite useful to measure the range and energy loss of heavy ions. These measurements are possible for all types of heavy ions provided the full range could be revealed as etched track in the detector. During the last fifteen years, various detectors, viz., CR-39, ZnP glass,Cellulose nitrate (CN) and Lexan polycarbonate with high sensitivity and resolution were identified and developed (Aschenbach et al, 1974; Fleischer et al.,1967 ; Cartwright et al., 1978; Kumar et al.,1987 ; Price et al., 1987 and Garg et al., 1988).

The shape and size of heavy ion tracks in these detectors are dependent on mass, charge and energy loss rate of the heavy ion.The track length of a heavy ion is very sensitive parameter of its energy (Dwivedi et al., 1986). Therefore , after suitable calibration ,these detectors can be used for measuring the energy,mean ranges and energy loss rate and for the identification of heavy charged particles.

EXPERIMENTAL DETAILS

The present investigation involves a number of glass detectors namely sodalime , phosphate and quartz for studying their etching characteristics

using heavy ion radiation damage. Glass samples of sodalime (microscopic slide), phosphate (LG-700) and quartz glass were irradiated with heavy ions at GSI heavy ion facility at Darmstadt, Germany and at JINR , Dubna (USSR). The samples were irradiated with ^{238}U, ^{131}Xe, ^{197}Au, ^{56}Fe and ^{48}Ti for different ion beam energies at varying incident angles . All these samples were subjected to chemical treatment with hydroflouric acid (HF) at a concentration of 20 % for different intervals of time . The mean observed track lengths (l') and diameter (D) of nearly 25 tracks were counted in each glass detector using a Carl Zeiss binocular microscope with a resolution of 1 um. The actual track lengths were calculated from the mean of the observed track length using the relation $l = l'/\cos\theta$, where θ is the angle of the incident beam on the detector surface . Only circular and elliptical tracks were counted whereas the inhomogeneities and dislocations which appear as tracks were ignored .

For the range measurements of heavy ions, these samples were etched for increasing time intervals and it was found that the cone length increased linearly with etching time until a final stage is reached when whole of the track length is revealed . This track length becomes constant with etching time and is called the experimental range of the heavy ion.

RESULTS AND DISCUSSION

A calibration curve is constructed by plotting the ion energy as a function of track length. The maximum ranges obtained experimentally are plotted for heavy ions at varying energies in different glass detectors (Fig. 1).The values of maximum ranges for different glass detectors are summarized in table 1

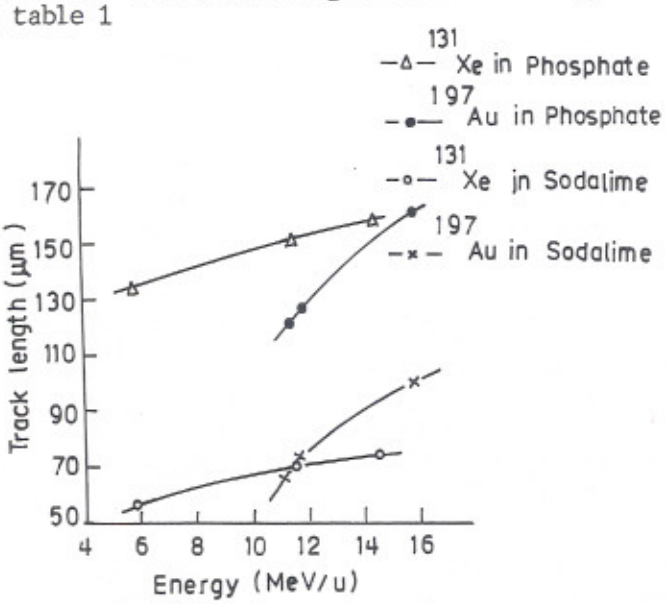

Fig. 1. Variation of track length versus energy of the beam for different ions.

The etching behaviour of sodalime, quartz and phosphate glasses has been studied to identify different ions used for irradiation. Fig. 2 shows the etching behaviour of ^{238}U ions having energies of 5.9 and 15 MeV/u respectively in phosphate glass detector . The distinct curves show the energy dependence of heavy ions in these glass detectors. Similar behaviour

(a) Sodalime

S.No.	Ion Beam	Energy(MeV/u)	Maximum Track Lengths(μm)
1	^{197}Au	15.96	100.40
2	^{238}U	5.9	76.50
3	^{131}Xe	14.5	74.50
4	^{197}Au	11.67	73.50
5	^{131}Xe	11.40	70.00
6	^{197}Au	11.40	68.25
7	^{131}Xe	5.9	57.50

(b) Quartz

S.No.	Ion Beam	Energy(MeV/u)	Maximum Track Lengths(μm)
1	^{197}Au	15.96	160.00
2	^{131}Xe	14.50	129.25
3	^{197}Au	11.67	125.00
4	^{197}Au	11.40	120.00
5	^{131}Xe	11.40	115.00
6	^{131}Xe	5.90	109.50

(c) Phosphate

S.No.	Ion Beam	Energy(MeV/u)	Maximum Track Lengths(μm)
1	^{238}U	15.00	160.00
2	^{131}Xe	14.50	156.25
3	^{238}U	5.90	152.25
4	^{131}Xe	11.56	150.25
5	^{131}Xe	5.90	138.75
6	^{56}Fe	4.00	31.75
7	^{48}Ti	4.00	18.75

Table 1. The values of maximum track lengths for different ion beams.

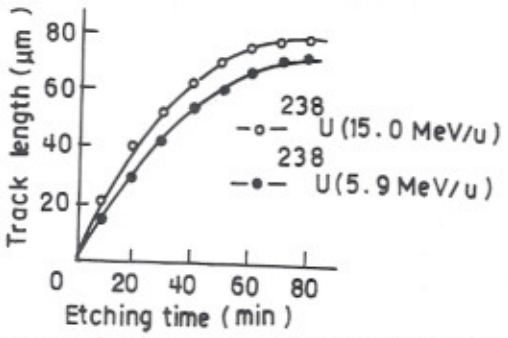

Fig.2 Variation of track length versus etching time for different energies using ^{238}U.

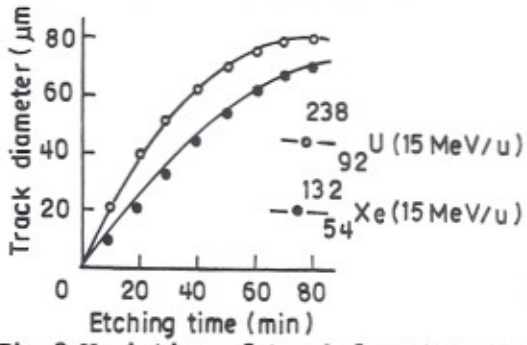

Fig.3 Variation of track length versus etching time for different ions.

is observed in quartz and sodalime glass detectors .

In order to study the charge resolution, phosphate glasses irradiated with $^{238}_{92}U$ and $^{131}_{54}Xe$ ions of energy 15 MeV/u were used . The variation of track diameter with time of etching is shown in fig. 3 . The observed curves are well resolved for a charge difference of 38 . Again similar behaviour is observed in quartz and sodalime glass detector.Hence the present study is quite useful for particle identification.

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