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ANNEALING OF HEAVY ION RADIATION DAMAGE IN SODA GLASS DETECTOR

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Abstract – Annealing behaviour of ^{208}Pb ion radiation damage tracks in sodalime glass detector is studied at three different angles using both length and diameter as track parameters. It is observed that the transverse annealing rate, dD/dt is lower than the longitudinal annealing rate, dl/dt. Obviously, the annealing rate increases with temperature and decreases with time but it is found to be independent of the angle of incident beam. The behaviour of sodalime glass detector during annealing of radiation damage is found to be isotropic.

1. INTRODUCTION

The nature of radiation damage and its healing in Solid State Nuclear Track Detector (SSNTDs) has been studied by various authors[1-8]. A number of models[9-12] have been proposed which explain the annealing kinetics as a function of both annealing time and temperature. Mark et al.[9] explained the annealing mechanism by a summation series of exponential decay functions and observed different activation energies corresponding to different ranges of temperature. However, they argued that a single activation energy is sufficient for the annealing process at higher temperature range.

A three step annealing model postulated by Modgil and Virk[12] explains the annealing behaviour of radiation damage in bulk materials. They proposed an empirical formula relating annealing rate, V_a and activation energy, E_a as follows:

$$V_a = At^{-n} \exp.(-E_a/kT) \qquad (1)$$

where A is proportionality constant, n the exponent of annealing time t, k the Boltzmann constant, and T the annealing temperature. According to this model it is the annealing rate, V_a, defined as the rate of change of length or diameter (i.e. dl/dt or dD/dt) and not the activation energy which varies with time and temperature. Rewriting eqn.(1), we have

$$\ln V_a = \ln A - n \ln t - E_a/kT \qquad (2)$$

The validity of this relation has been tested for annealing experiments on soda glass detector irradiated with fission fragments[13]. The authors favoured the concept of single activation energy of track annealing.

Recently, Green et al.[14] have also come out in support of the concept of single activation energy based on the results of annealing experiments on apatite.

The present study is undertaken to test the application of our model[12] to the annealing of radiation damage produced by heavy ions in soda glass detector for incident beams at different angles.

2. EXPERIMENTAL PROCEDURE

Samples of sodalime glass were irradiated at the GSI UNILAC heavy ion accelerator at Darmstadt using 17 MeV/n ^{208}Pb and 14.6 MeV/n ^{139}La ion beams at azimuth angles of 45°, 60° and 90°.

Isothermal and Isochronal annealing was carried out for time intervals of 10, 20, 40 and 80 m. and temperature intervals as 100, 150, 200 and 250°C. After annealing, each set was etched alongwith parent unannealed sample (to ascertain the range, lo and mean diameter D_o) under the optimum etching conditions in 2.5 % HF for 35 m at room temperature (30°C).

Track lengths and diameters were measured by optically scanning each sample using Carl Zeiss binocular microscope with a resolution of 1 µm. The track annealing rate, V_a, is determined for different angles of incident beams and at different temperatures (Table 1) from the observed mean lengths and diameters.

3. RESULTS AND DISCUSSION

The results on track annealing in terms of annealing rate, V_a using both track length and diameter as parameters are summarized in table 1. It has

Table 1. The values of transverse and longitudinal annealing rates for different incident angles using ^{208}Pb ion in Soda Glass detector.

T (°K)	$\frac{10^3}{K}$	90°		60°				45°			
		D(µm)	$V_a=\frac{dD}{dt}$	l(µm)	$V_a=\frac{dl}{dt}$	D(µm)	$V_a=\frac{dD}{dt}$	l(µm)	$V_a=\frac{dl}{dt}$	D(µm)	$V_a=\frac{dD}{dt}$
Unann.	-	16.50	-	28.00	-	14.00	-	28.17	-	11.00	-
323	3.09	-	-	26.00	0.2	13.00	0.1	26.05	0.21	10.00	0.1
373	2.68	15.00	0.15	23.00	0.5	11.50	0.25	23.24	0.49	8.50	0.25
423	2.36	13.80	0.27	19.00	0.9	9.50	0.45	19.72	0.85	6.50	0.45
473	2.11	12.10	0.44	14.00	1.4	7.00	0.70	14.08	1.41	4.00	0.70
523	1.91	10.50	0.60	7.00	2.1	3.50	1.05	7.04	2.11	1.00	1.00

been observed that the transverse annealing rate, dD/dt is lower than the longitudinal annealing rate, dl/dt. However, on plotting ln V_a against the reciprocal of annealing temperature (fig.1) it is found that the values of activation energies (Table 2) are the same irrespective of track parameters (length or diameter) chosen. It is interesting to note that the values of

Table 2. Identical values of activation energy of annealing for soda glass at different angles of incident beam.

	^{208}Pb(17 MeV/n)		
	90°	60°	45°
Activation Energy, E_a(eV)	0.160	0.16	0.16

activation energy and the exponent n of annealing time t(fig.2 and fig.3) show good agreement with those determined by Modgil and Virk[15] for fission fragments. However, there is some variation in A-values.

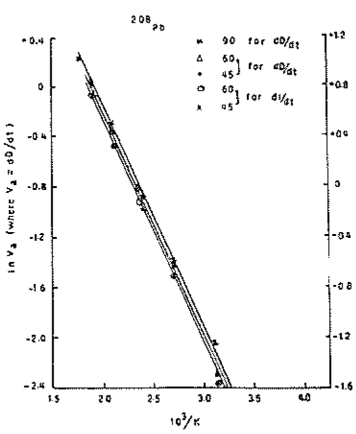

Fig.1 Plot of ln V_a vs 1/T at three different angles using ^{208}Pb ion.

An attempt is also made to carry out this work using 14.6 MeV/n ^{139}La ion irradiated soda glass detector. The values of E_a and n obtained from figs.4 and 5 are identical with those obtained using ^{208}Pb ion. The values of E_a, n and A are summarized in table 3.

Thus, the concept of single activation energy as an intrinsic property of

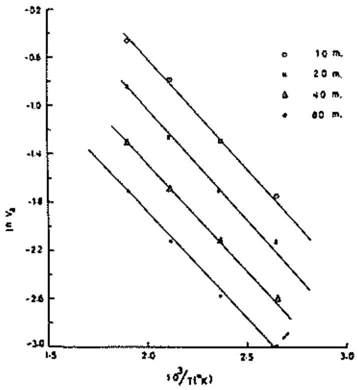

Fig.2 Plot of ln V_a vs 1/T at constant time using ^{208}Pb ion.

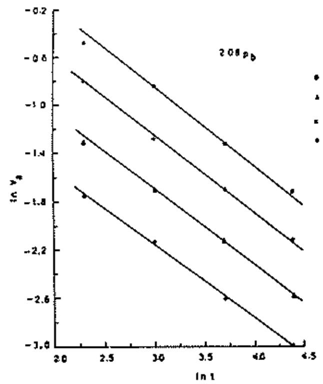

Fig.3 Plot of ln V_a vs ln t at constant temperature using ^{208}Pb ion.

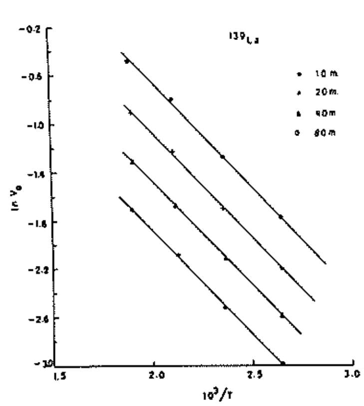

Fig.4 Plot of ln V_a vs 1/T at constant time using ^{139}La ion.

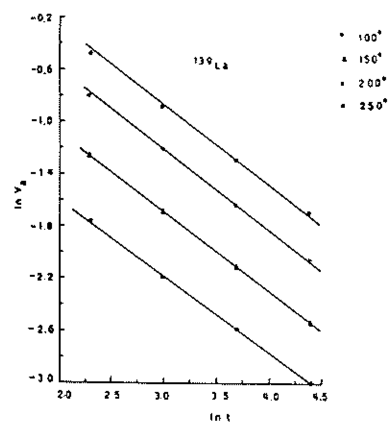

Fig.5 Plot of ln V_a vs ln t at constant temperature using ^{139}La ion.

Table 3. The values of E_a, n and A for different ion beams in Soda glass according to Modgil and Virk model.

Ion Beam	Activation Energy (eV)	n value	A value (μm/min)
^{208}Pb	0.15	0.58	67
^{139}La	0.15	0.56	60
fission fragments	0.16	0.65	95.6

the detector and independent of ion beam used and its angle of incidence seems to be fully justified.

REFERENCES

1. C.W. Naeser and H. Faul, Fission track annealing in apatite and sphene. J. Geophys. Res. 74, 705(1969).

2. G.A. Wagner and G.M. Reimer, Earth Planet Sci. Lett. 14, 263(1972).
3. R.L. Fleischer, P.B. Price, E.M. Symes and D.S. Miller, Fission track ages and track annealing behaviour of some micas. Science 143, 349(1964).
4. R.L. Parshad, H.S. Saini and K.K. Nagpaul, Can. J. Earth Sci. 15, 1924(1978).
5. K.K. Nagpaul, P.P. Mehta and M.L. Gupta, Pure App. Geophys. 112, 131(1974).
6. M. Dakowski, J. Burchart and J. Glazka, Bull. Acad. Polon. Sci. Ser. Sci. Terre, 22, 11(1974).
7. S.L. Koul and H.S. Virk, Min. J. of Japan 9, 55(1978).
8. S. Singh, A.S. Sandhu and H.S. Virk, Ind. J. Pure Appl. Phys. 23, 487(1985).
9. E. Mark, M. Pahl, F. Purtscheller and T.D. Mark, Tschermarks Min. Petr. Mitt. 20, 131(1973).
10. T.D. Mark, M. Pahl and R. Vartanian, Nucl. Technol. 52, 295(1981).
11. E. Dartyge, J.P. Daraud, Y. Langevin and M. Maurette, Phys. Rev. B23, 5213(1981).
12. S.K. Modgil and H.S. Virk, Nucl. Tracks 8, 355(1984).
13. H.S. Virk, S.K. Modgil and Gurinder Singh, Nucl. Instrum and Meth. in Phys. Res. B21, 68(1987).
14. P.F. Green, I.R. Duddy, A.J.W. Gleadow and P.R. Tingate, Nucl. Tracks 10, 323(1985).
15. S.K. Modgil and H.S. Virk, Nucl. Instrum and Meth. B12, 212(1985).