*Nucl. Tracks Radiat. Meas.*, Vol. 15, Nos. 1–4, pp. 239–240, 1988
*Int. J. Radiat. Appl. Instrum., Part D*
Printed in Great Britain

111 108

0191–278X/89 $3.00 + .00


# ANNEALING KINETICS OF HEAVY ION TRACKS IN CR-39

R.K. BHATIA and H.S. VIRK

SSNTD Laboratory, Department of Physics,
Guru Nanak Dev University,
Amritsar-143 005, India.

Abstract - Various models have been proposed in the recent past to understand annealing kinetics of radiation damage latent tracks in SSNTDs. Modgil and Virk proposed an empirical formula in terms of the annealing rate of the latent track. Later Price and co-workers introduced a single set of values for the terms involved in the above formulation by using a modified version of Modgil and Virk formula. The purpose of this study is to check the validity of the modified formula in case of plastic track detector CR-39 by using different ion beams of $^{93}$Nb (18 MeV/n), $^{139}$La (14.6 MeV/n) and $^{208}$Pb (17.0 MeV/n). Our results do not fully corroborate the findings of Price et al.

## 1. INTRODUCTION

The material of a charged particle track differs from that of the matrix in that it has been altered by the energy which the particle lost as it traversed the solid. A particle looses energy in different ways as it passes through matter. To understand the reconstruction of the damaged matrix, a number of authors[1-4] have introduced various annealing models. Dartyge et al.[1] using X-ray scattering methods on silicates analysed that latent tracks are constituents of extended defects, separated by gap zones loaded with point defects. Modgil and Virk[2] tried to conceptualize their model and its major inference is that the activation energy of annealing is a detector property (unique value for each detector), independent of the parameters of track forming particle. Their formulation

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

where $V_a$ is the annealing rate, dl/dt; n and T are exponents of annealing time and temperature respectively; A is a detector constant and $E_a$ is the activation energy for annealing; is found to be applicable to mineral and glasses. However, Salamon et al.[3] tried a crude interpretation of their model on the basis of bimolecular reaction rates. Price et al.[4] have given a modified version of the same formulation by using the concept of etch rate reduction on annealing, as it is quite difficult to measure instantaneous annealing velocities. Using fractional thermal fading rate, $(s-1)_i - (s-1)_f/(s-1)_i\, t_a$ as the new parameter in the L.H.S. of equation(1), given below in its modified form

$$\frac{(s-1)_i - (s-1)_f}{(s-1)_i\ t_a} = A\ t_a^{-n} \exp(-E_a/kT) \qquad (2)$$

they conclude that A, n and $E_a$, the parameters of the best fit, assume a single set of values for a given detector. This implies that L.H.S. of eqn.(2) is invariant for all ions under identical annealing conditions. They further state[4] 'Using this surprisingly simple formula, we can predict the thermal fading rate as a function of annealing time and temperature for any ion at any velocity in the interval tested.'

Our present study convincingly proves that the above sweeping statements of Price et al.[4] in support of Modgil and Virks[2] formulation should not be taken at their face value. We find some discrepancies using three different ion beams ($^{93}$Nb, $^{139}$La and $^{208}$Pb) in CR-39 plastic detector.

## 2. ANNEALING OF CR-39

Samples of CR-39(Pershore Mouldings) 250 μm thickness, were irradiated at the GSI accelerator (W. Germany) at incident angles of 45° and 90° to the surface. These samples were annealed in a muffle furnace with a temperature variation of ±1°C for different sets of temperature and time combinations. The annealed samples were etched in 6N NaOH in the Haake N3 circulator at a control temperature of 70°C. The annealed tracks were observed under a magnification of 400 using a Carl Zeiss binocular microscope. $V_B$ and $V_T$ are measured using standard techniques[5].

## 3. RESULTS AND DISCUSSION

Using the data available from $^{93}$Nb ion tracks for different sets of annealing times and temperatures, the values of $V_B$ and $V_T$ were calculated for CR-39. Using these values in L.H.S. of equation(2), and plotting them against corresponding annealing time and temperature intervals, we estimate A, n and $E_a$ (figs.1 and 2) the parameters of the fit. Following the statement of Price et al.[2] we use these parameters to compute the values of fractional thermal fading rate for $^{208}$Pb and $^{139}$La ion tracks in CR-39 detector; which must agree with value (0.66) obtained for $^{93}$Nb ions.

Surprisingly, the experimental values for $^{208}$Pb and $^{139}$La ions are 0.68 and 0.83, respectively. There is a clear discrepancy between the computed value and the experimental values. This variation indicates that one of the above parameters A, n or Ea should vary. We intend to extend our work further so as to pinpoint the variable on the R.H.S. of equation 2. As CR-39 detector shows some reciprocal effects in comparison to other plastics we also intend to check the formula in the domain of Lexan Polycarbonate.

## ACKNOWLEDGEMENT

The authors are grateful to Dr. J. Vetter, GSI, Darmstadt, for providing heavy ion irradiation facilities at the UNILAC accelerator. RKB has pleasure in thanking CSIR, for the financial assistance provided in the form of Senior Research Fellowship .

## REFERENCES

1. E. Dartyge, J.P. Durand, Y. Langevin and M. Maurette, Phys. Rev. B23, 5213(1981).
2. S.K. Modgil and H.S. Virk, Nucl. Instr. and Meth. 224, 217(1984).
3. M.H. Salamon, P.B. Price, J. Drach, Nucl. Instr. and Meth. in Phys. Res. B17, 173(1986).
4. P.B. Price, G. Gerbier, H.S. Park and M.H. Salamon - Systematics of Annealing of Tracks of Relativistic Nuclei in Phosphate Glass Detectors (personal communication).
5. R.L. Fleischer, P.B. Price and R.M. Walker, Nuclear Tracks in Solids, Principles and Applications, University of California Press, Berkeley.

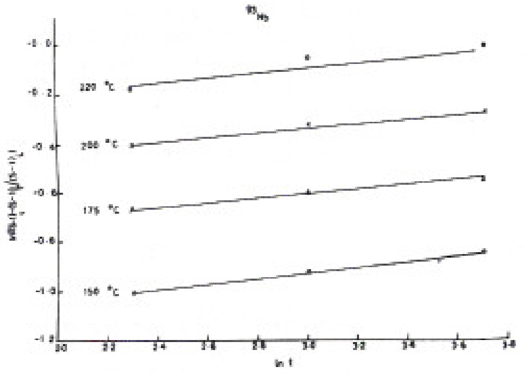


Fig.1

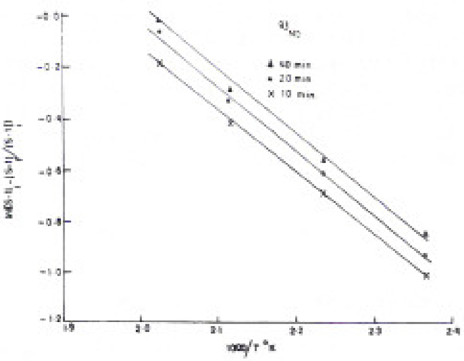


Fig.2