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POST-IRRADIATION ANNEALING IN PLASTIC DETECTOR CR-39

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Abstract - Thermal stability of latent damage trails due to 18 MeV/n ^{93}Nb ions in CR-39 detector was studied. The samples were annealed in the temperature range 100°C - 250°C for time intervals of 10 min., 20 min. and 40 min. and subsequently etched in 6N NaOH solution at 70° ± 1°C. The corresponding isochronal and isothermal track etch rates and bulk etch rates were observed. The correction was applied to track length due to etch rate variations of annealed samples and its implication for the proposed Single Activation Energy Model is discussed.

1. INTRODUCTION

The complexity of plastics renders it quite difficult to present a predictive theory to explain track damage fading in them. The annealing process can be further complicated by the fact that in addition to track etch rate, the bulk etch rate may also be affected by annealing, the latter due to environmental effects[1-3]. Bulk etch rate variations have been observed in Makrofol N[4], a polycarbonate, whereas Makrofol E[5] and Lexan[6] have been found to be stubborn to these variations. The literature concerning thermal annealing studies on plastics is rather sparse and the data so far reported are contradictory[7-8].

With this background, we started investigations on the most talked about plastic detector, CR-39. Here we present a detailed study of the dependence of etch rates-bulk and track -on the thermal exposure of the samples and its implications for re-interpretation of the Single Activation Energy Model .

2. EXPERIMENT

CR-39 sheets were exposed to 18 MeV/n ^{93}Nb ion beam using irradiation facility at UNILAC accelerator at GSI. These sheets were segmented into small parts containing at least an average of 30 tracks for the experimental study. The segmented samples containing latent tracks of ^{93}Nb ions were annealed in a temperature-controlled oven for a variety of time and temperatures. After annealing, these samples along with the control ones were etched in 6N NaOH at 70°C. To account for both bulk and track rate variation we introduced a method similar to the one given earlier by Dwivedi and Mukherji[9] for track etching. The annealed length, La, is estimated from the following expression:

$$La = \frac{L}{\cos\theta} + \frac{V_{bT}t}{\sin\theta} + V_{bT}(t-t_c) \qquad (1)$$

where L is the projected length, θ the angle of beam incidence; V_{bT} the bulk etch rate at a given temperature T, t the etching time and t_c the time of etching required to fully reveal the whole track length.

3. RESULTS AND DISCUSSIONS

On scrutinizing the results it becomes obvious that the bulk etch rate, V_B increases with the extent of annealing, as already observed elsewhere[10]. It is also observed that V_t variation is found to follow the traditional trend of decreasing with the amount of annealing.

Modgil and Virk[11] introduced the concept of single activation energy in their proposed model on annealing. The authors introduced a new parameter, track annealing rate, $V_a = dl/dt$ in place of the usual track length or density reduction parameter, in their formula

$$V_a = At^{-n} \exp(-E_a/kT) \qquad (2)$$

where n and T are the exponents of annealing time, t, and annealing temperature, respectively; A is a constant, E_a, the activation energy of annealing and k, the Boltzmann constant. This equation was successfully applied to minerals and glasses.

The aim of our study is to check the validity of the proposed model in plastics. This empirical formula[11] had not taken account of the variation of etch rates. We also ignored the variation in our pioneer attempt[12] to apply the formulation to plastic detector CR-39. To account for the effect of etch rate variations on track length, we have applied the formulation proposed by Dwivedi and Mukherji[9] for length measurements. These corrected lengths were hence used in the final inference. It is evident from figs. 1 and 2 that using eqn(1) for corrected annealed lengths, the data gives a best fit.

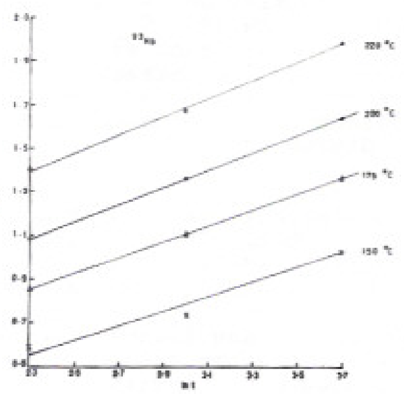

Fig.1 Variation of corrected annealing rate with time.

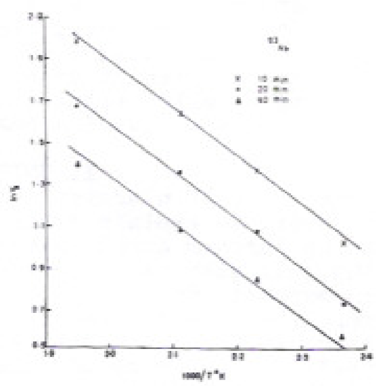

Fig.2 Plot between corrected annealing rate and temperature^{-1}.

We may hence conclude that irrespective of the mechanism of annealing in plastics, Ea, the activation energy of annealing is not only independent of the nature of ion beams used[11] but also of the annealing time intervals (fig.1) chosen.

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