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Annealing Study of Heavy Ion Tracks in Makrofol-N Using Electrochemical Etching Technique

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^{252}Cf fission fragment tracks in Makrofol-N were annealed and subjected to electrochemical etching keeping electrical and etching parameters constant for all observations. From diameter reduction rate, activation energy of annealing (E_a) is determined using empirical relation proposed by S K Modgil and H S Virk [*Nucl Instrum & Meth B (Netherlands)*, **12** (1985) 212]. Results obtained are compared with those of chemical etching and it is found that the values of E_a obtained independently by these two different techniques are in close agreement.

Conventionally, the annealing study of radiation damage is conducted by measuring the reduction in track length in chemically etched plastic solid state nuclear track detectors (SSNTDs). To reduce the measurement errors in track length, it is desirable to irradiate the detector with high energy ion beams in the basal plane or incident at low azimuth angles, to get long tracks.

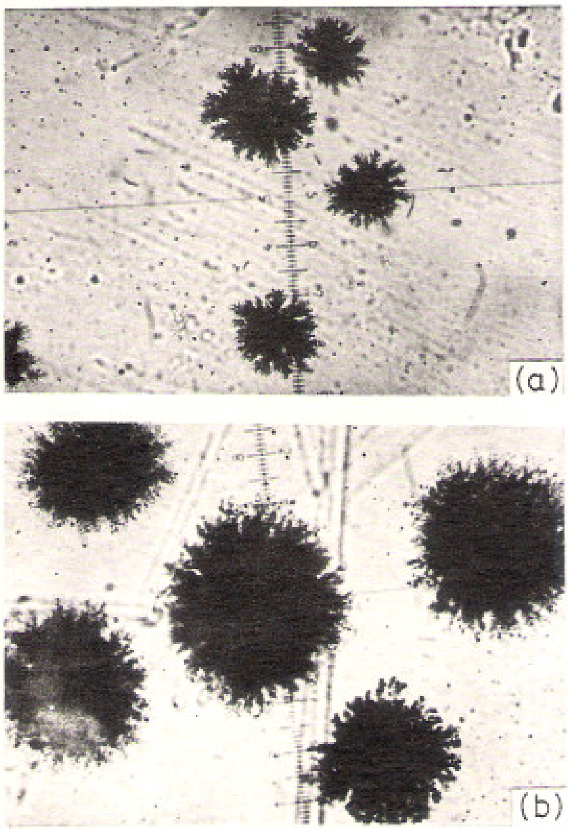

Fig. 1—Photomicrographs of electrochemically etched fission fragment tracks (a) annealed at 175°C and (b) unannealed

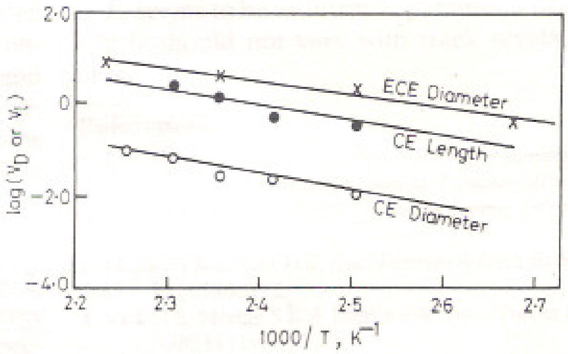

Fig. 2—Plots of log (V_D or V_l) vs 1000/T

In the present study, we have exploited electrochemical etching[1] to find the activation energy of annealing (E_a) using the single activation energy model proposed by Modgil and Virk[2]. Mathematically, the empirical relation in terms of track length or diameter reduction rate is given as:

$$V_l \text{ or } V_D = A\, t^{-n} \exp(-E_a/kT) \qquad \ldots (1)$$

where V_l and V_D are the annealing rates (given as dl/dt or dD/dt, l and D being the measured length and diameter, respectively), n is the exponent of time, E_a the annealing activation energy; k, T and t stand for Boltzmann's constant, annealing temperature and time, respectively. As E_a is independent of the ion[3], the results obtained are compared with that of post-annealing chemical etching of ^{129}Xe ion tracks.

In the first part of the experiment, foils of Makrofol-N of thickness 350 µm were irradiated with fission fragments of ^{252}Cf. The time of irradiation was chosen to get about 2000 tracks/cm^2, because high density of tracks is not desirable due to distortion effects[4]. The foils were isochronally annealed at different temperature intervals ranging from 100 to 175°C for 10 min each in an oven having an accuracy of ±1°C. The foils were electrochemically etched in 6.25 N NaOH keeping the etchant temperature constant at 40°C using Haake constant temperature bath. An ac field strength of 20 kV/cm at 2 kHz frequency was applied for a period of 2 hr for each case. Track diameters of both annealed and unannealed samples were measured with an optical binocular microscope. Typical photomicrographs of electrochemically etched fission fragment tracks, annealed

(175°C) and unannealed are shown in Fig. 1 (a) and (b) respectively.

In the second part of the experiment, Makrofol-N samples irradiated at the GSI UNILAC accelerator using ^{129}Xe ions at angles 45° and 90° were annealed as discussed above. The chemical etching was conducted under optimum conditions. The lengths and diameters were measured and statistical errors applied to get the correct values of V_l and V_D. Using Eq. (1), a plot of the annealing rates (V_l and V_D) vs $1/T$ was made for both the techniques (Fig. 2). The value of E_a is calculated from the plot of Fig. 2.

From the parallelism between the lines of Fig. 2, we conclude that the annealing activation energy (E_a) is a constant for a particular detector, irrespective of the technique used to reveal the tracks. The value of E_a in the present case is 0.655 eV. It is also evident from the figure that E_a is independent of the track parameters used. A comparison of the results obtained by ECE of fission fragments and chemical etching of post annealed ^{129}Xe ion tracks in Makrofol-N further supports our hypothesis[2] that E_a is independent of nature of ion[3,5].

E_a seems to be an intrinsic parameter of a detector which should not vary with track revelation technique.

References

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