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Efficiency Calibration and Effect of Etchant Temperature on Fission Fragment Tracks in Soda Glass Detector

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Track registration efficiency of soda glass detector for various etchant concentrations and the effect of temperature on track development have been studied. It is observed that the track etch rate decreases towards the end of the latent track. Mean track diameter is found to increase almost linearly with increase in etchant temperature up to 70°C after which it decreases rapidly. Etching efficiency varies from 0.42 to 0.44 with change in etchant concentration.

Introduction

GLASS detectors being simple and convenient are widely used for neutron fluence measurement in fission track studies.[1–5] For etched tracks to appear the angle of inclination of fission fragments with the glass surface must be greater than a certain critical angle,[6] $\theta_c = \sin^{-1} V_G/V_T$, where V_G and V_T are the bulk and track etch rates respectively. Etching efficiency η = 1-sin θ_c, is the fraction of fission fragment tracks that can be registered in a detector. For a given specimen, etchant and thermal conditions are the most important factors upon which the etching efficiency depends. The present study relates to the effect of temperature and concentration of etchant on track development properties.

Experimental Procedure

Glass samples were prepared from microscopic glass slide PIC-2 (Blue Star make). These were washed with alcohol and then with distilled water and dried in a dust free atmosphere. The samples were irradiated with ^{252}Cf fission fragment source of strength 1 μCi in 2π geometry in air for 2 min.

Specimen samples were etched with HF of concentration 48, 40 and 20% respectively for the duration ranging from 1–40 s at 30°C for the purpose of efficiency calibration. To study the effect of etchant temperature on track development, samples were etched in 48% HF for 5 s intervals at 0°, 28°, 50°, 70°, 80°, 90° and 98°C respectively. The experiment was repeated with the new etchant ($HF:H_2SO_4:H_2O$ 3:1:9) using etching interval of 5 min at corresponding temperatures. All measurements of etched track diameters were made under a binocular microscope (Olympus make) at total magnification of 1500×.

Track etch rate, V_T, is calculated from the slope of linear portion of the plot of track diameter vs etching time. For prolonged etching time, over which θ_c is not effectively constant, V_T is measured by using equation:

$$D = 2\,V_G t\sqrt{(V_T - V_G)/(V_T + V_G)} \qquad (1)$$

where D and t are the diameter and the etching time respectively.

Discussion and Results

For different concentrations of HF, track diameters are plotted vs etching time (Fig. 1). For low concentration (20% HF) track diameter varies linearly with etching time. At 40 and 48% HF the relation is linear in the beginning but the curve approaches a plateau value for prolonged etching. The plot of V_T vs etching time (Fig. 2) reveals that the track etch rate remains constant in the beginning but decreases for prolonged etching time and the V_T decreases towards V_G as the fission fragment approaches the end of its range. From this we can infer that radiation damage in latent tracks is not uniform over the whole range. Values of critical angle and etching efficiency for soda glass detector are given in Table 1. Our results are in agreement with the theoretical and experimental values reported by KHAN and DURRANI[3,8] for the same etchant concentration. It can be concluded (Table 1) that etching efficiency for track revelation in soda glass detector increases for low etchant concentration (20% HF). It is therefore advisable that for better results etching should be done using low etchant concentration and prolonged etching times.

The effect of etchant temperature on track development in soda glass detector (Fig. 3) shows that with

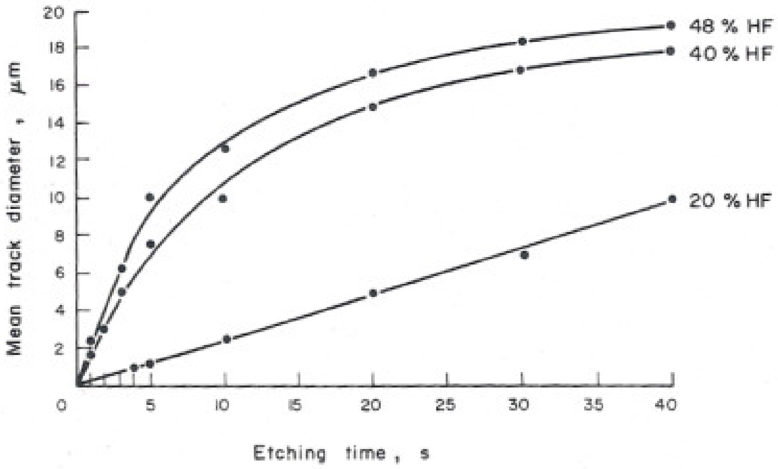

FIG. 1. Variation of mean track diameter with etching time for ^{252}Cf fission tracks in soda glass detector.

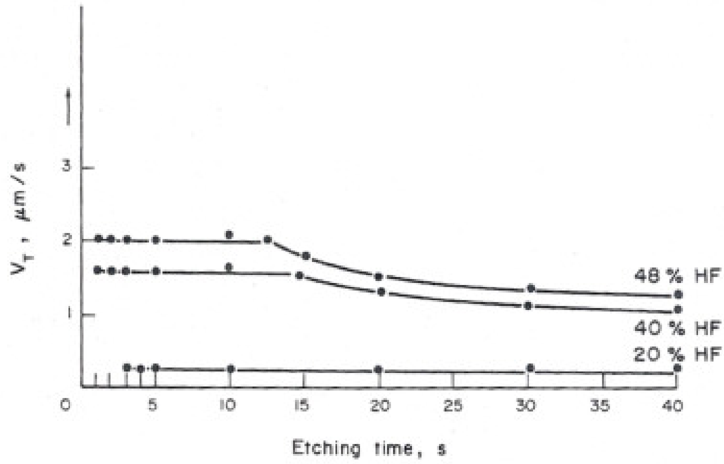

FIG. 2. Track etching rate, V_T, vs etching time in soda glass detector irradiated with ^{252}Cf fission fragments.

TABLE 1. Etching parameters for sodalime glass detector

Sr. No.	Etchant* conc.	Bulk etch rate V_G (µm/s)	Track etch rate V_T (µm/s)	Critical angle θ_c	Etching efficiency η
1	48% HF	1.15	2.0	35°-15′	0.42
2	40% HF	0.90	1.54	35°-30′	0.42
3	20% HF	0.14	0.25	34°-03′	0.44

* Etching temperature 30°C.

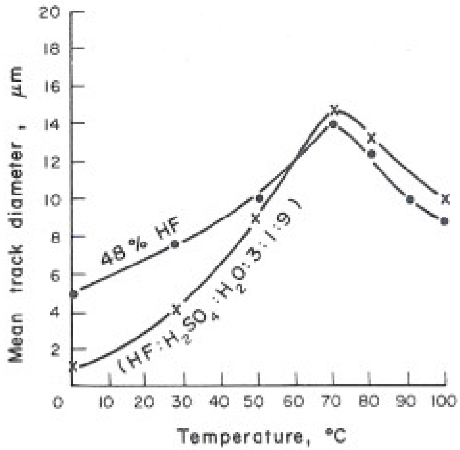

FIG. 3. Variation of mean track diameter with temperature in soda glass detector etched with 48% HF and ($HF:H_2SO_4:H_2O$ 3:1:9) for 5 s and 5 min respectively. The acids used are of 12 and 24% conc. respectively.

the increase in temperature the mean track diameter increases almost linearly up to 70°C. YADAV *et al.*[9] report a decrease of largest observable track diameter with increase in temperature up to 72°C on the basis of EPLs (etch product layers). Our results prove that in spite of EPLs formed during the etching of soda glass, the track diameter continues to increase with temperature up to 70°C.

At higher temperatures the decreasing trend in track diameter sets in due to the following two reasons: (i) V_G increases at a faster rate with rise of temperature and (ii) the radiation damage of latent tracks is not uniform over the whole range.

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