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TRACK ANNEALING STUDIES IN MUSCOVITE MICA

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Abstract - The effect of crystallographic structure on the annealing behaviour of heavy ions radiation damage in muscovite is reported. It has been found that the tracks lying parallel to the cleavage planes are much more resistant to thermal annealing than those lying perpendicular to the cleavage planes. The activation energy (E_a) is found to vary with the incident angle. However, for a given dip angle the value of E_a seems to be independent of the nature and energy of incident ion.

1. INTRODUCTION

It has been shown earlier[1] that the annealing of fission fragment tracks normal to the surface of muscovite proceeds more rapidly than those which are nearly parallel to cleaved surface. Bull and Durrani[2] attributed this effect to the directional differences in the diffusion coefficients of the atomic defects associated with the damage trail. Crystalline minerals have a regular atomic structural arrangement and the atomic spacing is quite variable along different crystallographic directions. It has been shown earlier[3-4] that the value of activation energy in apatite and quartz varies considerably with crystallographic orientation in the same crystal. The present study investigates the track annealing kinetics in muscovite detector in order to see the influence of crystallographic structure on activation energy of track annealing.

2. EXPERIMENTAL PROCEDURE

Different sets of samples prepared from muscovite were exposed to ^{238}U (10 MeV/n), ^{93}Nb (18 MeV/n) and ^{208}Pb (17 MeV/n) ion beams from the UNILAC accelerator at GSI Darmstadt, West Germany, at 15° and 75° angles of incidence w.r.t. the detector surface. Another set of samples from muscovite was irradiated with collimated beam of fission fragments from ^{252}Cf source in vacuum chamber. The irradiated samples were heated at various temperatures ranging from 350 to 700°C, for 10 min intervals. The unannealed samples were etched in 48 % HF to reveal full residual track lengths. The track lengths were measured at each temperature with an Olympus binocular microscope and the results are shown in Fig.1(a-d). The following empirical relation[5]:

$$V_a = At^{-n} e^{-Ea/kT} \qquad (1)$$

is used to determine the activation energy (Ea) for different ions. The track annealing rate (V_a) is calculated from the relation:

$$V_a = dL/dt \qquad (2)$$

assuming that V_a remains constant over the first 10 min of heating. Plot of $\ln V_a$ vs 1/T for different ions are shown in Fig.2(a-d). The values of Ea are given in Table 1.

3. RESULTS AND DISCUSSION

The experimental data on annealing of heavy ion tracks in muscovite fully satisfies the empirical relation proposed by Modgil and Virk[5]. A comparison of Ea for different dip angles (Table 1) shows that the minimum energy

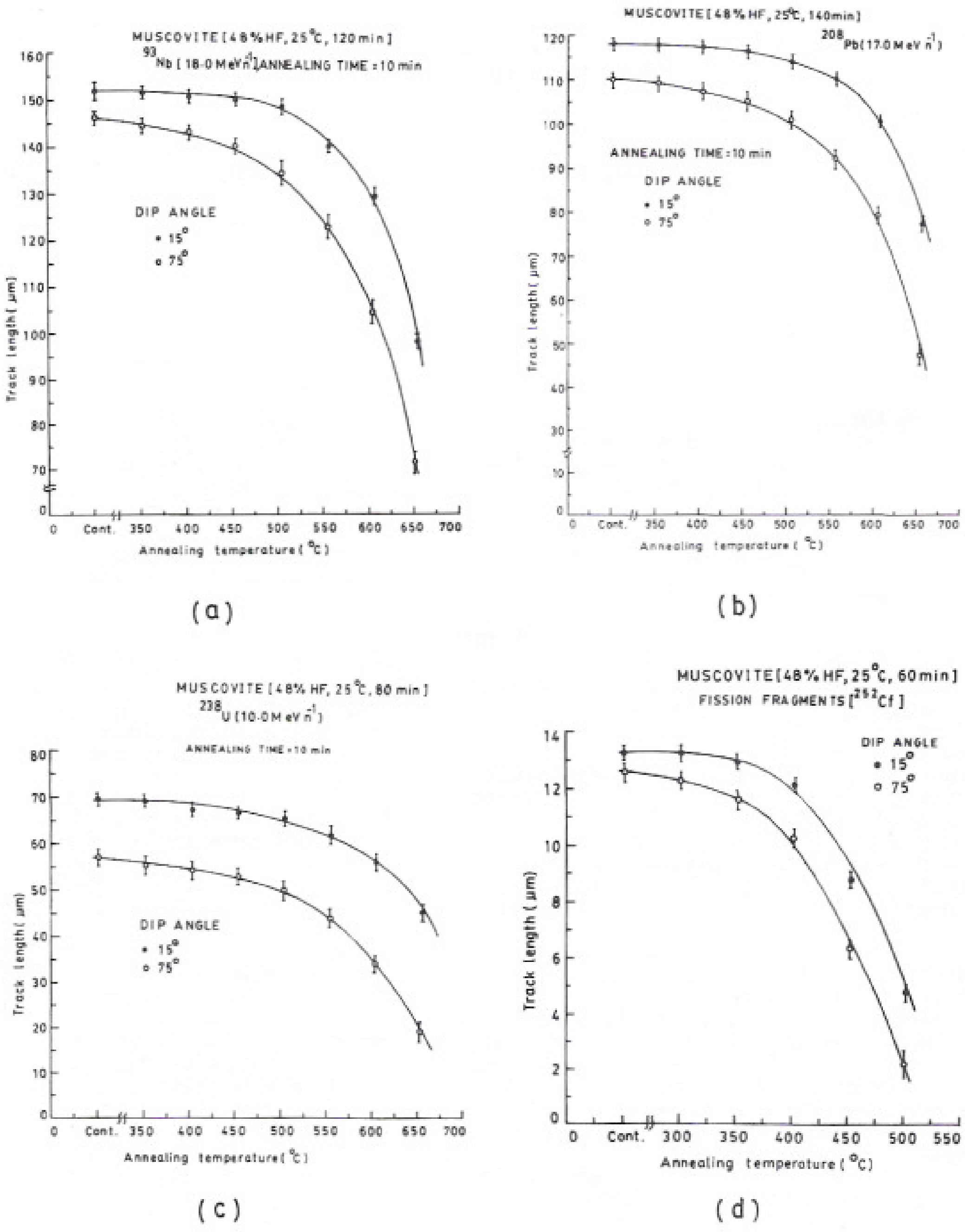

Fig.1. The variation of mean length of (a) ^{93}Nb (b) ^{208}Pb (c) ^{238}U and (d) fission fragment tracks with annealing temperature for different dip angles in muscovite.

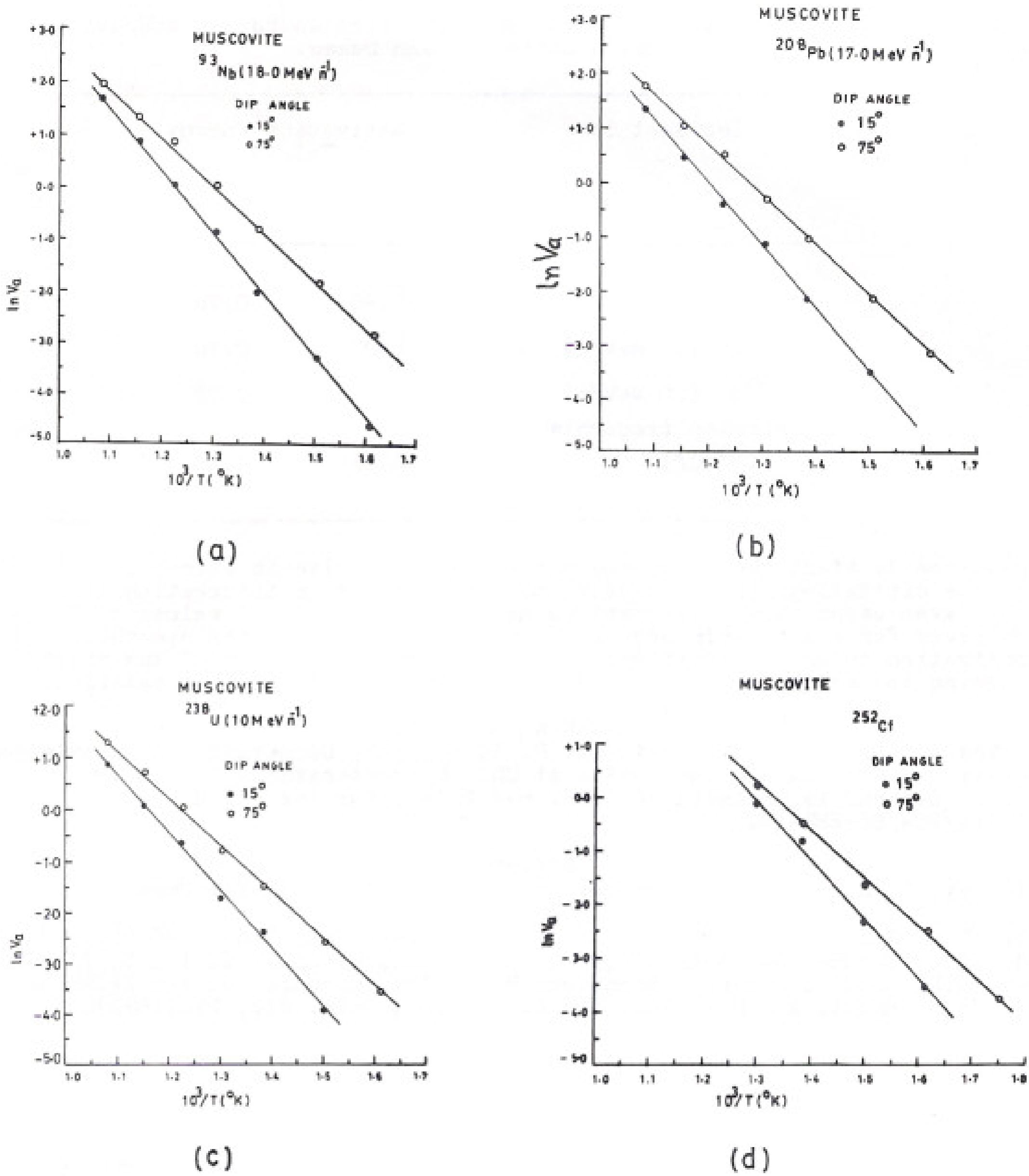

Fig.2. Plot of lnVa vs 1/T for (a) ^{93}Nb (b) ^{208}Pb (c)^{238}U and (d) fission fragment tracks in muscovite.

Table 1. The value of activation energy in muscovite using different ion beams.

Incident ion	Activation energy Ea(eV) 15°	Activation energy Ea(eV) 75°
^{93}Nb (18 MeV/n)	0.98	0.78
^{208}Pb (17 MeV/n)	0.97	0.78
^{238}U (10 MeV/n)	0.97	0.79
Fission fragments (^{252}Cf)	0.96	0.78

required to start the annealing process in muscovite is strongly controlled by the crystallographic orientation. However, it is interesting to note that even using three different beams of ions, identical values of Ea are observed for a given dip angle. This further supports the hypothesis[5] that activation energy is independent of the nature and energy of the track forming ion and is a characteristic property of the detector material.

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