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ON REGISTRATION PROPERTIES OF INTERCAST COMPANY CR-39

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1. INTRODUCTION

The solid state nuclear track detector, CR-39, the organic compaund poly(allyldiglicol)carbonate (Cartwright et al.,1978), has been found to have a wide application in numerous fields because of its high sensitivity to charged particles.

In detecting and identifying an unknown particle by given detector one should know its response to particles of known charge and energy. Nowadays, one of the track formation models, called REL-model (REL-restricted energy loss) (Benton and Nix,1969), satisfies more or less the experimetal data. By following this model a simple relation between the etch rate ratio, V ($V=V_T/V_B$, V_T is a track etch rate, V_B is a bulk etch rate), and REL has been found as follows: $V=1+\alpha \cdot REL^{\beta}$ (Somogyi et al.,1976). However, the function of the above form can be utilized in the limited REL range because CR-39 response curve has two distinct regions, light and high ionization regions (for example Khan et al.,1983). The coefficients α and β are different for each of them. This short paper presents results on response CR-39 which can be described by the function including the combination of two power terms.

2. EXPERIMENTAL DETAILS

The CR-39 samples of a thickness about 1.4 mm were casted by the Intercast Company of Parma (Italy). Table 1 gives the experimental conditions under present investigation. The particle energies, with the exception of ^{19}F, were degraded by means of aluminium foils. The detectors were etched in 6N NaOH at 70° ± 1°C during proper time to measure track parameters with suitable accuracy. The semiautomatic image analyzer, MOP-Videoplan (Austria),

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combined with the optical microscope, Carl Zeiss, Jena (Germany), was used for track parameters measurements. The bulk etch rate, V_B, was determined by two independent methods: track diameter measurements of highly ionizing particles and method of weighing. It is worth noting that there is a good possibility for precise determination of V_B by the above-mentioned methods (Henke et al.,1986). First, taking into account the condition that $V_t \gg V_B$, one can use the following relation (Somogyi and Szalay,1973)

$$V_B = \frac{D_{Ar}}{2 \cdot t}, \qquad (1)$$

where D_{Ar} is a track diameter of normally incident ^{40}Ar ions at Bragg peak and t is the etching time. Second, other method is based on the measurements of sample masses before and after etching. We have used a sample of 3 x 4 cm^2 in size and analytical balance accuracy was 0.05 mg. In order to remove the absorbated moisture a sample was kept in dessicator during few days before and after etching. The following results were obtained: V_B=1.15±0.02 μm/h by using track diameter measurements and V_B=1.16±0.06 μm/h by using weight method. It is clear that both the values are in good agreement.

The etch rate ratio, V, was determined by track diameter measurements of normally incoming particles as well as track length measurements in oblique geometry of irradiation. One should note that method of diameters is practically to be used at V≤3, for V≥3 this method is unacceptable, so the measurements of skew track lengths should be used (Somogyi et al.,1976).

The etch rate ratio, V, for ^2H, ^4He, ^{12}C and ^{19}F was determined from the following relation (Fleischer et al.,1975)

$$V = \frac{1+(D/2 \cdot V_B \cdot t)^2}{1-(D/2 \cdot V_B \cdot t)^2}, \qquad (2)$$

where D is a track diameter of normally incident particle. For incompletely etched ion tracks ^{12}C, ^{16}O and ^{20}Ne, till range end, entering in detector at an angle of 45° and totally etched ion tracks

Table 1. The experimental conditions under present investigation

Particle	Source of irradiation	Maximal energy of particle E (MeV/nucleon)	Angle of incidence with respect to the detector surface θ (deg.)
^2H	Cyclotron Y-200	9.1	90
^4He			90
^{12}C			90 and 45
^{16}O			45
^{20}Ne			45
^{40}Ar	Cyclotron Y-400	13.7	90 and 30
^{19}F	Synchrophasotron	3200	90
All the irradiations are performed at JINR, Dubna, USSR			

Table 2. Examples of V values determination for carbon tracks entering in detector normally and at an angle

E (MeV/nucleon)	V ± σ_V*	Method of V determination
9.1	2.42±0.11	by track diameters
7.0	3.06±0.19	
9.1	4.44±0.13	by track lengths
6.9	5.69±0.15	
*σ_V is a standard deviation from mean value of V		

^{40}Ar, rounded tips of tracks, entering in detector at an angle of 30° relative to detector surface, V values were determined from measurements of track lengths, according to Henke and Benton, 1971.

REL values were calculated by method of Henke and Benton, 1968 using ω_o = 200 eV (ω_o is a maximum energy of knock-on electrons).

3. RESULTS AND DISCUSSION

In Table 2 the examples of V values determination for carbon tracks entering in detector normally and at an angle are presented. The etching was being carried out during the same time - 10 hours. V values obtained by length meaurements significantly increase V values obtained by those of diameters. Thus, for plotting of response curve, starting from carbon the V values determined only by track lengths were taken into account.

In the Figure the reduced etch rate ratio, V-1, versus REL_{200} is presented. The experimental results were best fitted by the following function

$$V = 1 + \alpha_1 \cdot REL_{200}^{\beta_1} + \alpha_2 \cdot REL_{200}^{\beta_2}, \quad (3)$$

where α_1=2.955, β_1=1.068, α_2=0.047 and β_2=3.371.

One should note that etch rate ratio is changing together with decreasing of ion velocity in plastic. That is why, in order to average V values over ionization produced by particle along trajectory, calculated values of REL_{200} were referred to the point at a half track length relative to unetched surface of the detector.

One should also note that the CR-39 detector of Intercast Company is more stable to vacuum conditions of irradiation in comparison with detectors of other producers (Golovchenko and Tretyakova, 1991). This important characteristic is in favour of the given detector, as the experiments with heavy ions are often carried out in vacuum.

4. CONCLUSION

In the given paper the response function of CR-39 detector of Intercast Company is determined in a wide range of the ionization change. The results obtained allow further particle identification to be carried out.

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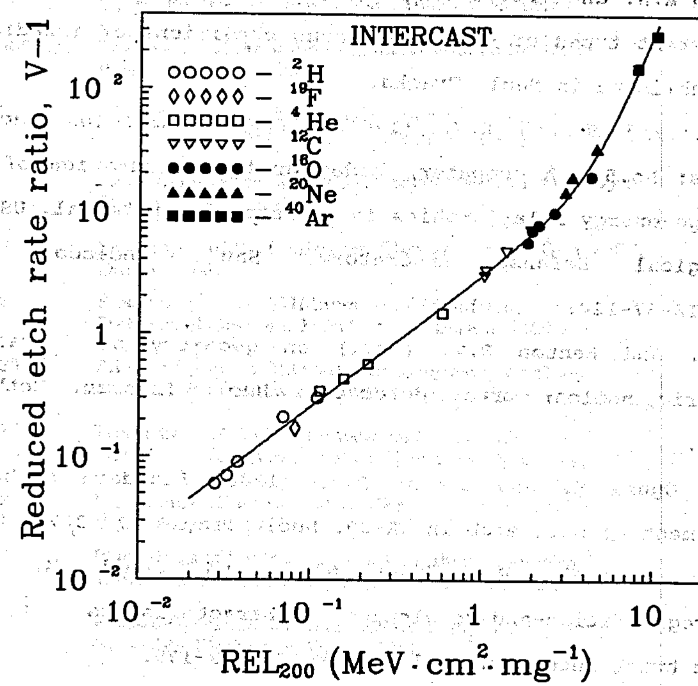

Figure. The reduced etch rate radio, V-1, versus REL_{200}: the points are the experimental values and the solid line is presented by formula (3).

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