Chinese Journal of Physics 54 (2016) 314–317

Contents lists available at ScienceDirect

Chinese Journal of Physics

journal homepage: http://www.journals.elsevier.com/chinese-journal-of-physics/

Fragmentation cross sections of 788A MeV ^{28}Si on carbon and polyethylene targets

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ARTICLE INFO

Article history:
Available online 13 May 2016

ABSTRACT

The total charge-changing cross sections and the partial cross sections of silicon ions on carbon and polyethylene targets are studied at 788 A MeV by using CR-39 plastic nuclear track detectors. The results are compared with other experimental and theoretical results. The obvious even-odd effect for partial cross sections is observed.

1. Introduction

Fragmentation of heavy ion on different targets at low, intermediate and high energies is very necessary in the fields of nuclear physics, astrophysics, radiobiology and radiotherapy, etc. It provides a way to clarify the reaction mechanisms in heavy ion collisions and the distribution of valence protons, particularly for neutron-rich projectiles [1]. Heavy ion fragmentation is also important to understand the origin, acceleration mechanism, and propagation of high energy galactic cosmic rays (GCR). The chemical composition of GCR in interstellar space is significantly altered because of fragmentation of heavy ions while interacting with interstellar medium [2]. Hence, it is necessary to have accurate values of fragmentation cross section for the production of fragments by heavy ion in various medium. It is, however, a huge task which can never be completed because of more precise composition of the GCR. Though the heavy ion component of GCR are less abundant than protons and helium, they are considered to be significant for their higher relative biological effectiveness. The health risks of space radiation is a serious challenge to astronauts on long duration spaceflight. The contribution of silicon to the dose equivalent in free space is second only to that of iron [3]. Further, silicon ions are also produced abundantly in the fragmentation of iron ions and other heavier ions. Therefore the fragmentation cross sections of silicon ions on various targets are of considerable importance. Fragmentation cross sections of heavy ions on different targets at intermediate and high energies have been measured by many research groups [3–16]. But the results of ^{28}Si ions on different targets at energies from several hundred A MeV to several A GeV are relatively less [3–7]. Furthermore, the total charge changing cross sections and the partial charge changing cross section both are not well agreement with each other. In this paper, the total charge changing cross sections and partial charge changing cross sections for projectile fragment production in the interactions of 788 A MeV ^{28}Si with C and CH_2 targets sandwiched with CR-39($C_{12}H_{18}O_7$) detectors are studied. The experimental results are compared with other experimental results at different beam energies and the predictions of theoretical models.

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http://dx.doi.org/10.1016/j.cjph.2016.05.003

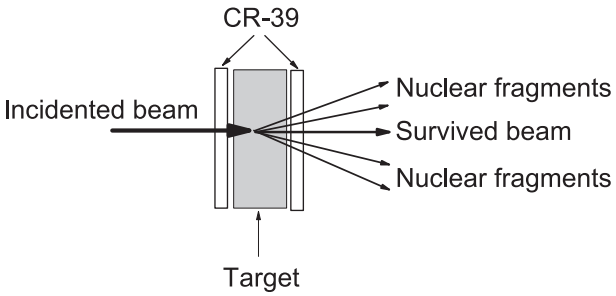

Fig. 1. Sketch of the target-detector configuration for this experiment.

2. Experimental details

Stacks of C and CH_2 targets sandwiched with CR-39 detectors(HARZLAS TD-1) were exposed normally to 788 A MeV ^{28}Si beams at the Heavy Ion Medical Accelerator in Chiba (HIMAC) at the Japanese National Institute of Radiological Sciences (NIRS). A CR-39 sheet, about 0.77 mm in thickness, is placed upstream and downstream of a target respectively. Fig. 1 shows the sketch of the target-detector configuration for this experiment. The thickness of carbon and polyethylene targets is 5 and 7 mm, respectively.

All detector sheets were etched in 7 N NaOH solution for 15 h at 70 °C. Track scanning and measurements were performed by means of the HSP-1000 microscope system and the PitFit track measurement software. The PitFit software allows us to extract some geometric information, such as the position coordinates, major and minor axes and area of etched track spot on CR-39 surfaces. The projectile trajectories and the ones of secondary projectile fragments are reconstructed, details of identification of charge of fragments can be found in our earlier publication [9–11]. Fig. 2 shows the track base area distributions of ^{28}Si ions and their fragments (on C target) in the CR-39 sheet. Peaks for ^{28}Si ion and each fragments with charge from Z = 5 to Z = 13 appear clearly. Because of the sensitivity of CR-39 detector, the tracks of projectile fragments with charge Z > 4 can only be measurable.

3. Experimental results

The total charge-changing cross sections of 788 A MeV ^{28}Si ions on the C and CH_2 targets were computed using the relation [5].

$$\sigma_{tot} = \frac{A_T \ln(N_{in}/N_{out})}{\rho_T D N_{AV}}, \tag{1}$$

where A_T, ρ_T and D are the mass number, density, and thickness of the target material, respectively. N_{AV} is the Avogadro's number. N_{in} is the number of incident ions, N_{out} is the number of survived ions after the target.

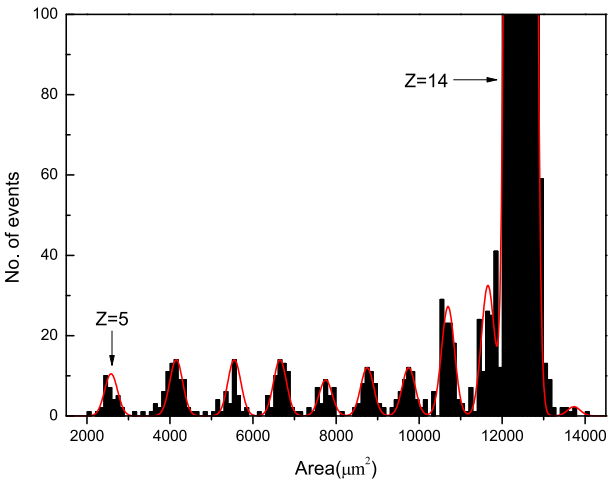

Fig. 2. Distribution of the etched cone areas for CR-39 detectors located after the carbon target.