CR-39 NUCLEAR TRACK DETECTOR APPLICATION FOR THE DIAGNOSTICS OF LOW ENERGY HIGH POWER ION BEAMS

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Abstract

This report presents the investigation results of spectral composition of ion beams generated by magneto-insulated ion diode of «MUK-M» and «TEMP» accelerators [1,2]. Energetical and mass characteristics of the accelerated ion beam were determinated by Thomson spectrometer with CR-39 plate detector (MOM-Atomki Nuclear Track Detector, Type MA-ND/p). Accelerated ion energy was from 40 up to 240 keV. Ion current density range is from 1 A/cm^2 up to 10 A/cm^2. Mass composition contained hydrogen, nitrogen, carbon and aluminum ions. The individual track analysis shows the track form, depth and diameter dependence on ion mass and energy.

Introduction

During last years we use CR-39 nuclear track detector (NTD) as a detector plate in Thomson spectrometer for the determination of accelerated ion beams' mass and energy spectra (Isakov et al., 1991, Matvienko et al., 1994) [1,2]. The ion energy, mass and atomic number of accelerated ion are determinated by the spectrometer construction.

Experiment

Research was carried with the ion beams generated by «TEMP» and «MUK-M» accelerators (Isakov et al., 1991)[1]. Ion beam composition is hydrogen, carbon, nitrogen and aluminum ions. Ion current range is from 1 A/cm^2 up to 100 A/cm^2. Ion energy is from 30 up to 300 keV/z. The mass and energy spectra of accelerated ion beam were determinated from the analysis of the common picture of NTD parabola tracks, determinated by Thomson spectrometer (fig.1). We used optical microscope for this research. Detector picture size was 1x1.5 cm.

Wide range of ion energy in the beam spectrum is defined by the particularities of the ions accelerating. Ion beam was collimated by two 50 μm diameter diaphragms. Into the Thomson spectrometer chamber, ion beam was separated and makes traces on detector surface as a system of parabolas, every one corresponds to the certain kind of ions with equal A/z ratio, where A - atomic number of element, z - ion charge. After irradiation by the polycomponent ion beam, detector plate was etched by 6.28 N NaOH solution at t=60°C. Etching time was 1-6 hours.

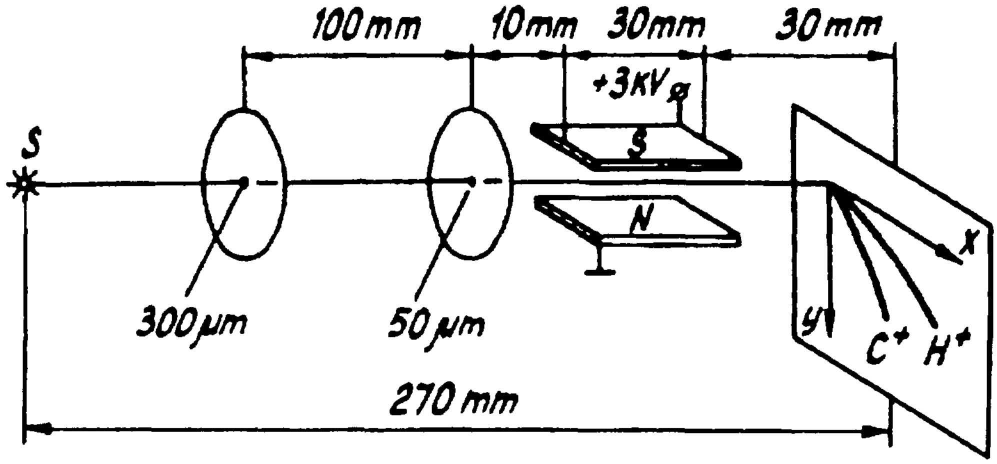

Fig.1. The principle of Thomson ion spectrometer.

The research of the individual ion track characteristics was carried in the electron microscope by investigation of carbon replica tracks on CR-39 detector plate, using the information about beam composition and ion energy. Fig.2 presents a typical photospectrogramm of CR-39 detector plate image and the electron photomicrographs of carbon replica profiles of ion tracks.

As a result of analysis of ion track after separation in Thomson spectrometer on detector plate, we have defined ion beam composition as a following: hydrogen ions (energy range is from 40 up to 120 keV) are 26 per cent, single and double charge carbon ions (energy range is from 80 up to 240 keV) - 70 per cent, nitrogen ions (energy range is from 60 up to 120 keV) is approximately 4 per cent. Wide range of ion energy in the beam spectrum is defined by the particularities of the ions accelerating. The low limit of the observed ion energy spectrum is limited by spectrometer construction. It is 30 keV. Individual ion tracks in the detector have almost regular form of the circle in the section, but depth is small. The ion track diameters depend on ion mass and ion energy. H^+, C^{+n} track diameters after 6 hours etching are 1-1.8 μm, track depths is from 0.13 up to 0.19 μm. This diameter dependence on energy is linear. The diameter dependence on mass is not observed distinctly. The track diameter and track depth from nitrogen ions are 2 times higher than analogous parameters for carbon and hydrogen ions in the same ion energy range. Obtained results are correspond to results (Sato et al., 1990)[3] and allow to make a conclusion about perspective using of this type detector for the low ion beams.

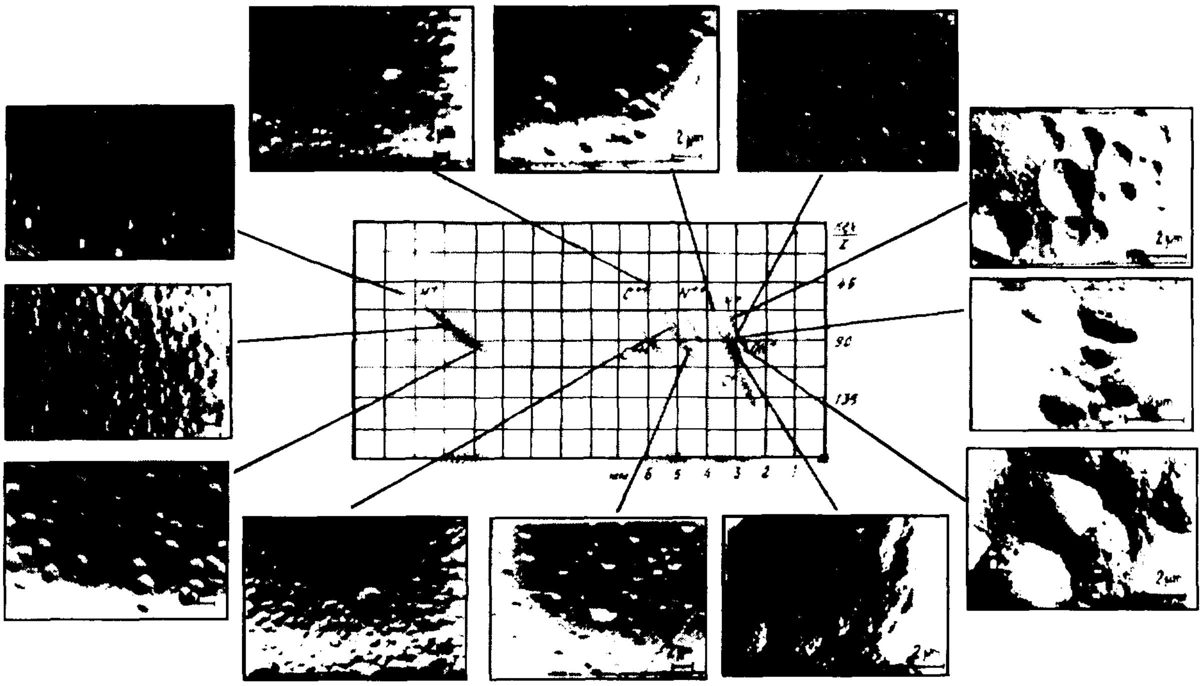

Fig.2. The typical photospectrogramm of CR-39 detector plate image and the electron photomicrographs of carbon replica profiles of ion tracks.

Conclusion

It is possible to use Thomson spectrometer with CR-39 NTD as a method for detector sensitive properties' calibration for different mass and energy ions. It is possible because processes of the detector etching, detector irradiation by different mass and energy ions and track identification are carried simultaneously[4,5].

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[5]CR-39 Nuclear Track detector Application for the Diagnostics of Low Snergy High Power Ion Beams. G.E.Remnev, M.S.Opekunov, A.N.Grishin, I.V.Ivonin. Radiation Measurements, Vol.25, Nos1-4, p.739-740, 1995.