THE PEKING UNIVERSITY MULTI–APPLICATION ION BEAM ANALYSIS SYSTEM

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ABSTRACT

A multi–application ion beam analysis system and some research projects performed at this system are described. The lifetime of the RF ion source for He^- is discussed.

Keywords: Tandem Ion beam analysis RF ion source

I. DESCRIPTION OF THE SYSTEM

Our ion beam analysis system consists of a Model 5SDH–2 tandem accelerator from NEC (USA) and two multi–function target chambers designed by ourselves. Fig.1 shows a layout of the system. The system is equipped with an RF ion source and a sputter source. They can provide H^-, He^-, and most of the negative heavy ions up to Au^-. The terminal voltage of the accelerator is adjustable from 0.15 to 1.7 MV. The

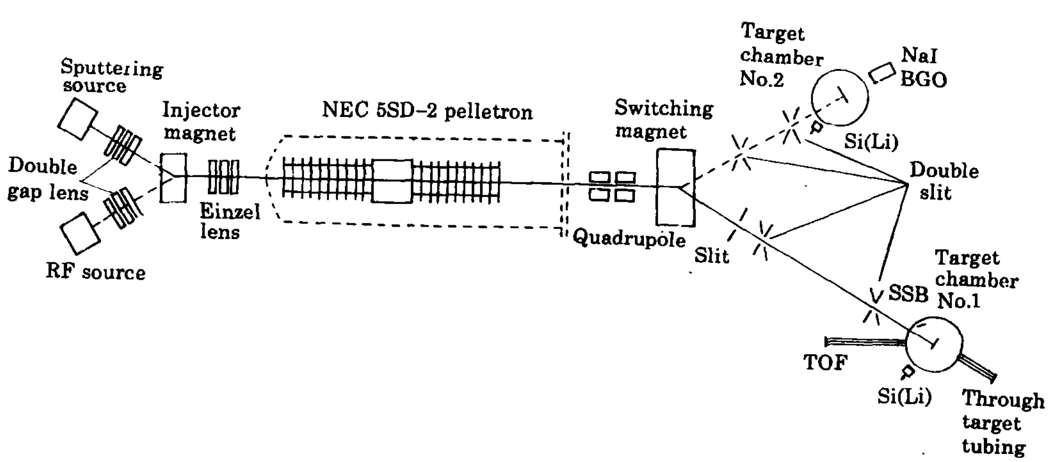

Fig.1 Layout of the system

switching magnet has seven beam ports, the mass–energy product of which is 300 u · MeV at 15°. The functions of the two installed beam lines are shown in Table 1. The table indicates that the system has functions of analyzing the full-element and the capability of analysis with heavy ion beam. It is also used for low energy nuclear physics experiments. The programs for data processing and simulating of PIXE and RBS, for example, RUMP, TRIM, *etc.* have been loaded in VAX 730 and IBM PC- XT computers as well.

Table 1

Analysis and experiment capability of the system

Function	Beam	Target chamber	Detector
Proton induced X-ray emission (PIXE)	Proton	No.2	Si(Li)
Nuclear reaction analysis (NRA)	Proton	No.2	NaI, BGO
	Heavy ions		HPGe
		No.1	S S B
Ion implantation	H, Helium	No.2	
	Heavy ions		
Rutherford backscattering (RBS)	Helium	No.1	S S B
Channeling analysis (CA)	Helium	No.1	S S B
Elastic recoil detection analysis (ERDA)	Helium	No.1	S S B
Heavy ion induced X-ray emission	Heavy ions	No.1	Si (Li)
Heavy ion RBS	Heavy ions	No.1	TOF
Heavy ion ERD	Heavy ions	No.1	TOF
			E-ΔE
Low energy nuclear physics experiment	H, Helium	No.1	NaI, BGO
	Heavy ions		HPGe

II. WORK CARRIED OUT

Since March 1988, this system has operated for 1000 h. According to the

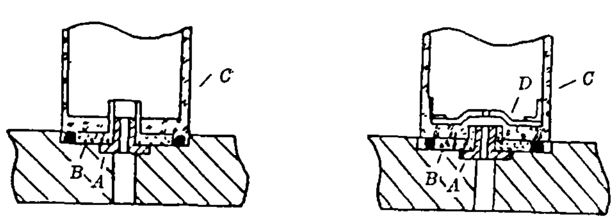

Fig.2 Extraction geometry for the original source on the left and the improved one on the right

A-canal *B*-BN insulator *C*-quartz bottle *D*-Ta sheet

requirements of the experiments performed H^-, Li^-, B^-, F^-, Si^-, Cl^-, Ni^-, Cu^-, Pd^-, Au^-, *etc.* have been extracted from the sputter source. Hundreds of samples have been analyzed. They include the measurements of trace elements in chinese berbal medicines, river water, wool and other biological samples; RBS and channeling analysis of microelectronic devices and superconductor materials; measurements of hydrogen profile in microelectronic materials and of fluorine content on the surface of certain machine parts made from zirconium and so on.

Besides the routine analysis mentioned above, other projects carried out are shown in Table 2.

Table 2

Projects carried out and results

Project	Result
Measurement of stopping power of heavy ions in some solid material using RNRA and ERDA methods	Ref.[1]
Investigation of silicide formation and phase transformation induced by ion beam mixing	Ref. [2, 3]
Study of properties of TiN film materials	Ref.[4]
Influence of different backing materials on lifetimes in Doppler–Shift Attenuation measurements	Master's thesis
Study of formation of semiconductor defects generated by high energy ion implantation	Master's thesis
Analysis of the trace element Se in human hairs and the dependence of the cancer on it	In progress
Experimental study of range distributions generated by multi–energy combination MeV implantation	In progress
Heavy ion induced atomic inner shell process and heavy ion induced X–ray emission	In progress

III. LIFETIME OF THE RF ION SOURCE

About 40% of the work use an RF ion source which provides He^- beam. But the lifetime of the source is too short (average 30 h) because of condensation of a conducting layer on the inner surface of the BN insulator and fracture of the carbon canal. The extraction geometry of the source is shown in Fig.2. The carbon canal failure is because of the rubidium vapor condensed on it. The carbon absorbs the rubidium which eventually leads to the damage of its structure and fracturing of the canal. In addition, when the plasma density near the extractor and the extraction voltage are higher, i.e. the beam power accepted by the canal is greater, the failure of the canal appears more easily. On the other hand, as the inner surface of the BN insulator was coated a conducting layer by sputtering, the decline in the insulating quality becomes a main problem. When the probe current I_p is increased to 15 mA, BN insulator have to be replaced. In order to decrease sputter the extracted He^- was limited within 800nA. For solving the problem we improved the extraction configuration of the RF source. A tantalum sheet with a small hole was fixed at the bottom of the quartz bottle (Fig.2. on right). The plasma emission surface is formed at the hole. So the vacuum space between the hole and the end of the canal replaces a part of the original BN insulator. Then there is no conducting problem of the insulator. Experiments showed that the improved source ran normally. The extracted beam is stable. I_p is only 0.1- 0.2 mA. But the maximum He beam is only 400nA, because the diameter of the hole in the Ta sheet is small (ϕ 2.3mm) and the parameters of the extraction configuration are not optimum. By adjusting the geometry parameters and changing the sheet material, a long lifetime and a higher He beam are expected.

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