Available online at www.sciencedirect.com
ScienceDirect
Nuclear Instruments and Methods in Physics Research B 260 (2007) 114–118
NIM B
Beam Interactions with Materials & Atoms
www.elsevier.com/locate/nimb

New capabilities of the Zagreb ion microbeam system

M. Jakšić *, I. Bogdanović Radović, M. Bogovac, V. Desnica, S. Fazinić, M. Karlušić, Z. Medunić, H. Muto, Ž. Pastuović, Z. Siketić, N. Skukan, T. Tadić

Ruđer Bošković Institute, Bijenička 54, P.O. Box 180, 10002 Zagreb, Croatia

Available online 13 February 2007

Abstract

The installation of a new 1.0 MV Tandetron accelerator and a recent upgrade of the 6.0 MV Tandem Van de Graaff accelerator increased the application possibilities of the Zagreb ion microbeam system. Several ion sources enable now the selection of a wide variety of ions. Most of them can be focused by the existing microprobe system. Sample positioning tools and new scanner control options are implemented in the new generation of SPECTOR data acquisition system. Details of the upgrades are presented.

PACS: 41.85.Lc; 29.17.+w

Keywords: Heavy ions; Data acquisition; Tandem accelerator; Nuclear microprobe

1. Introduction

During the last two years several technical improvements of our accelerator facility, including associated microprobe system, have been implemented at the Laboratory for Ion Beam Interactions. We expanded our activities from development and applications of materials characterization techniques to research of processes important for materials modification by ion beams. We have concentrated our interests to interactions of heavy ions with materials, having in mind the high stopping power and therefore high energy that heavy ions can transfer to the target material in very short time and small volume. Heavy ions have the largest nuclear energy loss in the sub MeV energy range, while the largest electronic energy loss is found at ion energies of more than 1 MeV/u. Fig. 1 shows a functional dependence of electronic and nuclear contribution to the stopping power as calculated by SRIM [1] for ^{35}Cl ions in silicon. As it is well known, the largest energy transfer to surrounding nuclei is observed for low energies (here between 10 and 100 keV), while the largest energy transfer by electron stopping contribution is achieved for energies above 35 MeV. In Fig. 1 it is also seen that the energy loss of protons in that respect is much smaller and less favorable for materials modification when the large energy transfer is required. ^{35}Cl ion beam is frequently used as it can be easily produced in negative ion sputtering sources.

In order to provide reliable and stable production of heavy ions in both low and high energy range, an upgrade of the old 6.0 MV Tandem, as well as the installation of a new low energy Tandem, has been performed.

2. Accelerators

2.1. 6.0 MV Tandem

The old 6.0 MV Tandem Van de Graaff was installed in 1987 after donation and transport from the Rice University, Houston, TX. Until 2006 its main task was to provide proton and other light ion beams accelerated with up to 3 MV terminal voltage for typical ion beam analysis requirements. Recently, at the beginning of 2006, a new set of inclined field accelerator tubes was installed. These changes enabled a stable operation at much higher voltages (up to 6.0 MV) with negligible radiation and secondary

* Corresponding author. Tel.: +385 1 4680 942; fax: +385 1 4680 239.
E-mail address: jaksic@irb.hr (M. Jakšić).

0168-583X/$ - see front matter
doi:10.1016/j.nimb.2007.01.252

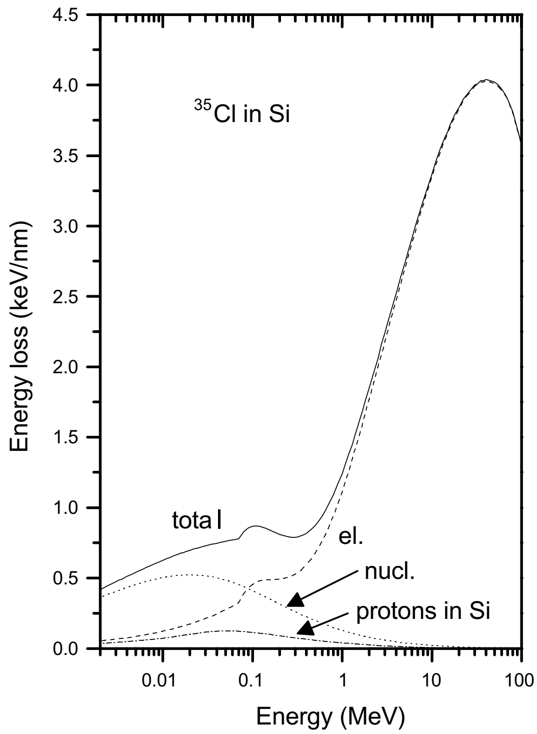

Fig. 1. SRIM calculation of ^{35}Cl ion energy loss in silicon, indicating energy regions of high nuclear and electronic contribution to the total energy loss.

electron load and therefore much easier and more reliable work with heavy ions. Two ion sources, Alphatross (normally used for hydrogen, deuterium and helium) and sputtering (used for a range of elements such as hydrogen, lithium, carbon, oxygen, silicon, chlorine and others) can provide the majority of ion beams needed in our research.

The first EN Tandem application of heavy ion beams with energy greater than 1 MeV/u was tested after the recent installation of the new ERDA system [2]. This recently commissioned spectrometer was developed on the basis of a TOF (time-of-flight) detection system. The spectrometer is flange mounted and can be moved as a whole unit from the ERDA end-station to the forward 37.5° angle port dedicated to ERDA at the ion microprobe scattering chamber [3]. Currently this port is occupied by the IEE ERDA system module developed previously for hydrogen 3D analysis [4]. In such a way 3D ERDA analyses of other elements heavier than hydrogen may be possible as well.

The other important upgrade has been achieved by the implementation of a new computer control for the 6.0 MV Tandem accelerator. Software based on TestPoint package [5] has been developed in the Laboratory using a set of AD/DA/DIO modules [7]. Each module is equipped with eight input and eight output 16 bit channels, as well as eight digital input and eight digital output channels, programmed to control accelerator components. This system has been in particularly important for applications where ions and/or energies have to be changed in a short time. In such cases, the recalculation of beam optical parameters is performed automatically. One such application is irradiation of a sample by different ions of the same rigidity. This is of importance for example for the creation of radiation damage in silicon at different depths between 3 and 10 μm and can be achieved by using subsequently Li and O ions [6].

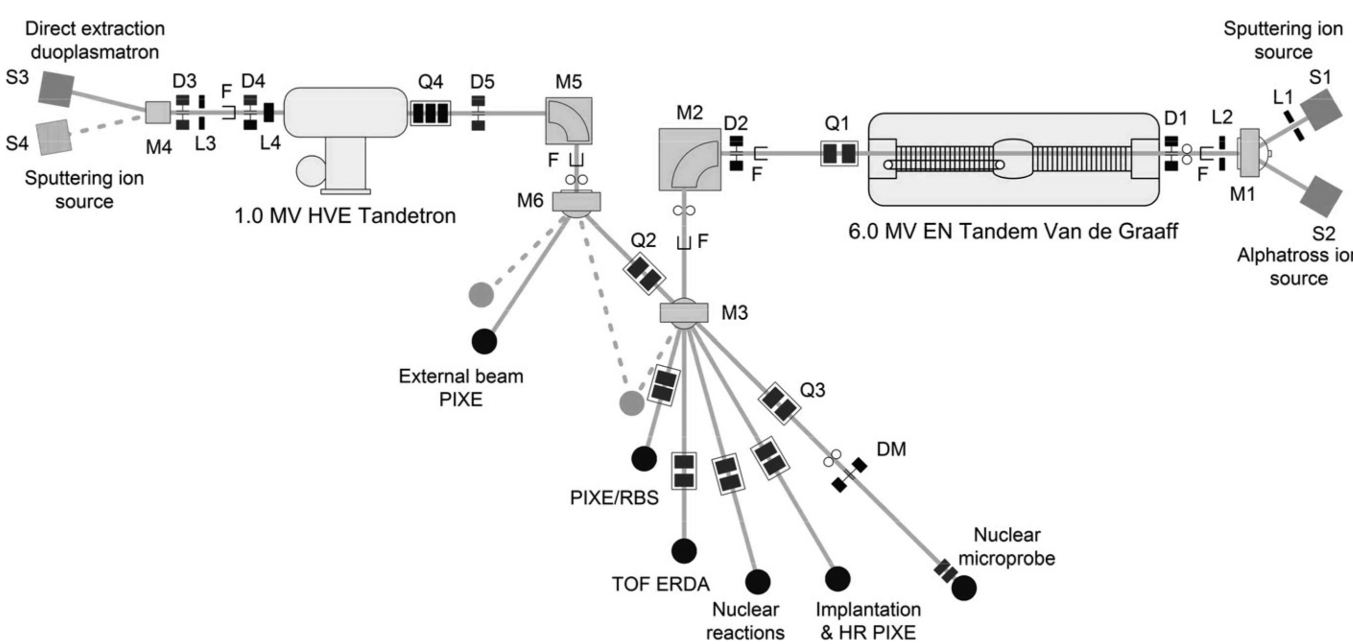

Fig. 2. Layout of the accelerator facility and beam lines at the Ruđer Bošković Institute. System elements are labeled as: S, ion source; L, electrostatic lens; D, electrostatic or magnetic deflector; M, dipole magnet; Q, quadrupole magnet; F, Faraday cup.