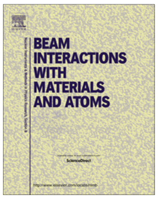
Nuclear Instruments and Methods in Physics Research B xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Nuclear Instruments and Methods in Physics Research B

journal homepage: www.elsevier.com/locate/nimb



A new ion-beam laboratory for materials research at the Slovak University of Technology

Pavol Noga *, Jozef Dobrovodský, Dušan Vaňa, Matúš Beňo, Anna Závacká, Martin Muška,
Radoslav Halgaš, Stanislav Minárik, Róbert Riedlmajer

Slovak University of Technology in Bratislava, Faculty of Materials Science and Technology in Trnava, Advanced Technologies Research Institute, Trnava, Slovakia

ARTICLE INFO

Article history:
Received 10 December 2016
Received in revised form 24 March 2017
Accepted 14 April 2017
Available online xxxx

Keywords:
Ion implantation
Accelerator
Ion beam analysis
Ion beam

ABSTRACT

An ion beam laboratory (IBL) for materials research has been commissioned recently at the Slovak University of Technology within the University Science Park CAMBO located in Trnava. The facility will support research in the field of materials science, physical engineering and nanotechnology. Ion-beam materials modification (IBMM) as well as ion-beam analysis (IBA) are covered and deliverable ion energies are in the range from tens of keV up to tens of MeV. Two systems have been put into operation. First, a high current version of the HVEE 6 MV Tandetron electrostatic tandem accelerator with duoplasmatron and cesium sputtering ion sources, equipped with two end-stations: a high-energy ion implantation and IBA end-station which includes RBS, PIXE and ERDA analytical systems. Second, a 500 kV implanter equipped with a Bernas type ion source and two experimental wafer processing end-stations. The facility itself, operational experience and first IBMM and IBA experiments are presented together with near-future plans and ongoing development of the IBL.

1. Introduction

Development of ion beam technologies at the Slovak University of Technology in Bratislava (STU) dates back to the 1960's, and was focused to the field of microelectronics. The first ion-beam laboratory in Bratislava was running a 1 MV Van de Graaf ion accelerator, which was later reduced to 300 kV and in the late 1980's upgraded to a terminal voltage of 0.9 MV with a Cockroft-Walton high voltage cascade and was equipped with analytical (RBS, PIXE, NRA) and ion implantation end stations [1]. At the time of its closure in 2013, the new facility was already under construction in Trnava and was commissioned in December 2015.

Research at STU using ion beams was focused mostly on irradiation response of materials, particularly magnetic metallic glasses and nanocrystalline alloys [2–4], radiation hardness and damage studies of nuclear reactor materials [5,6] including Generation IV fission reactors [7–11] as well as fusion reactor materials within the ITER project [12], ion-beam transport [13–15] and the utilization of IBA methods for materials analysis [16].

Recent investments in ion beam technologies supported by the European structural funds, enabled to broaden the available ion beam energies, covering the range from 40 keV to several tens of MeV, which will be used for low- and high-energy ion implantation and material analysis.

2. Equipment and capabilities

Two accelerator systems have been put into operation, a 6 MV Tandetron™ accelerator and a 500 kV open-air ion implanter, both supplied by High Voltage Engineering Europa, Amersfoort.

2.1. The 6 MV Tandetron system

The system is based on a 6.0 MV coaxial High-Current Tandetron™ Cockroft-Walton type accelerator [17], equipped with two ion sources and two end-stations, layout shown in Fig. 1. The ion sources are (i) a SO358 type duoplasmatron with a coated mesh platinum filament delivering hydrogen and helium ion beams. Negatively charged hydrogen ions are extracted directly from the source with currents up to several tens of μA, helium ions are extracted in He+ or He2+ state and passed through a sodium-vapour fed charge exchange canal, delivering a negative He beam current of up to 5 eμA. Standard extraction voltages are 30 kV for hydrogen ions and 20 kV for helium ions; (ii) a SO860C type caesium sputtering ion source with a spherical tungsten ionizer capable of delivering negative ion beams of species ranging from hydrogen to bismuth. Standard extraction voltage is 30 kV.

---

* Corresponding author.
E-mail address: pavol.noga@stuba.sk (P. Noga).

http://dx.doi.org/10.1016/j.nimb.2017.04.051
0168-583X/

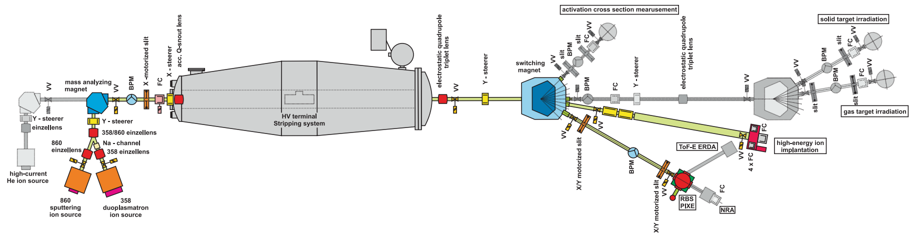


Fig. 1. Layout of the 6 MV Tandetron™ system. Items with solid contours is the actual configuration, items with dashed contours are planned in near future Abbreviations: VV – Vacuum Valve, FC – Faraday Cup, BPM – Beam Profile Monitor, HV – high voltage, ToF-E – time-of-flight-energy.

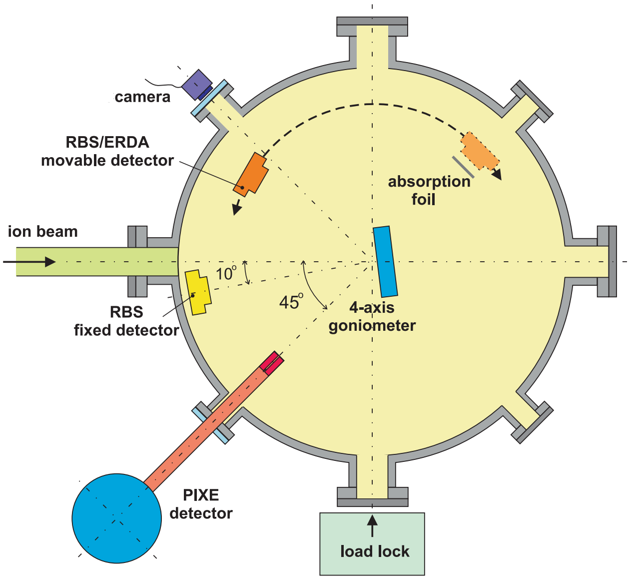


Fig. 2. Configuration of the IBA end-station.

The ion implantation end-station is capable of processing substrates of up to Ø100 mm, with the possibility of sample heating up to 800 °C and cooling down to LN2 temperature. The IBA system (Fig. 2) is equipped with two ion implanted silicon charged particle detectors, one fixed at 170° with respect to the ion beam axis, used for RBS/channelling, the other movable used for RBS/ERDA, which with an absorption foil placed in front of it is used for hydrogen concentration measurements, and finally the PIXE HPGe X-ray detector situated at 135°. For sample positioning, the end-station is equipped with a four-axis goniometer with a 0.01° positioning precision in the three rotational axes and 0.01 mm in vertical translation.

It is also worth to mention, that the 6 MV system is located in a heavily radiation-shielded room enabling in the future to perform experiments generating considerable neutron as well as gamma radiation fields.

2.2. The 500 kV open-air implanter

The 500 kV ion implanter (Fig. 3) is equipped with a Bernas ion source capable to deliver species ranging from hydrogen to bismuth including noble gases, with ion-beam currents of up to 2–3 mA. Positively charged ions are extracted directly from the ion source with a standard extraction voltage of 40 kV and after the desired mass is selected by a mass separation magnet, the beam is accelerated by an up to 460 kV potential. The ion source enables three ion generation methods: (i) in case of gases, they are ionized directly in the arc-discharge plasma, (ii) sputtering by Ar of BF_3 is used to extract ions from solid species and (iii) an evaporator is available for low-melting/evaporation temperature materials (e.g. phosphorus or antimony). Two end-stations for ion implantation are available, one being the same model as described above, the other one is capable of processing substrates of up to Ø200 mm and is equipped with a manipulator enabling to set the implantation angle in the range from 0° to 45°, water cooling and a provision for helium backside gas cooling.

3. Results and discussion

We have tested both systems running beams of various ion species within the available energy range. First experiments were among others a 25 MeV Cu implantation, high-fluence (over 1.5×10^{18} at/cm^2) 100–500 keV Co and Cu implantation for ion beam synthesis purposes and IBA analyses. First IBA experiment

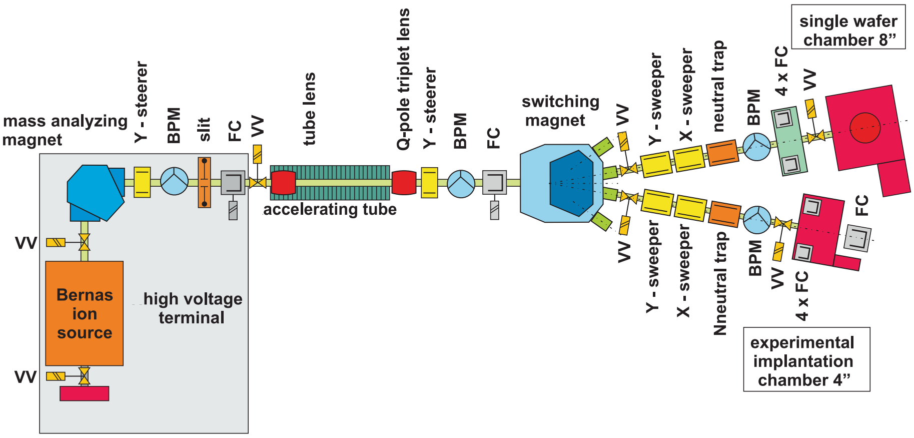


Fig. 3. Configuration of the 500 kV open-air implanter. Abbreviations as in Fig. 1.

Please cite this article in press as: P. Noga et al., A new ion-beam laboratory for materials research at the Slovak University of Technology, Nucl. Instr. Meth. B (2017), http://dx.doi.org/10.1016/j.nimb.2017.04.051