



Contribution ID: 24

Type: **not specified**

# Ion Beam Analytical Techniques at iThemba LABS

The Ion Beam Analysis (IBA) division at iThemba LABS conducts materials research for applications in information technology, electronics, air pollution, and energy. To this end, we make use of the various facilities at the Tandetron and Tandem Laboratories for synthesis, modification, and analysis of thin films and nanostructured materials. The analyzed materials range from semiconductors and oxides to metals and magnetic materials. These materials are investigated to optimize their structural, electronic, magnetic, and optical properties. The IBA division delivers specialized ion beam analytical expertise, materials characterization services and products to government, industry, and academia. Instrumentation for materials research at iThemba LABS include, amongst others, 3.0 MV Tandetron and 6 MV Tandem accelerators, a 200 KV ion implanter, nuclear microprobe facilities, a RF/DC sputtering unit, a dual electron beam evaporator system and high temperature furnaces. These ion beam analytical facilities ensure that the Tandetron and Tandem Laboratories continue to be at the forefront of accelerator science applied to materials research. These facilities are used annually by over 100 researchers and users including post-graduate students. These users include researchers from a variety of scientific disciplines at South African universities and other research organizations, and a number of international collaborators. As one of the IAEA Collaborating Centres we are committed to hosting researchers and scientists from the African continent and elsewhere, committed to organizing regional and international training workshops and schools for students and young researchers.

## Research Infrastructure

### *Rutherford Backscattering Spectrometry (RBS)*

The RBS analysis technique is used mostly for determining the composition and the depth distribution of elements by aligning the crystallographic axes of the sample to the incoming alpha particles and RBS channelling analysis provides information about the crystal structure of the sample.

### *Elastic Recoil Detection Analysis (ERDA)*

In ERDA recoiled ions scattered off a thin film by an energetic heavy ion beam impinging the surface at a glancing angle are detected under forward direction and analysed for their nuclear charge or mass and energy.

### *Particle-Induced X-ray Emission (PIXE)*

Charged particles are used to create inner-shell vacancies in the atoms of the specimen. Protons of 1-4 MeV energy are mostly used. Their slowing down in matter is smooth and well characterized, with little scattering and deflection. PIXE spectra are usually collected in energy-dispersive mode and all elements with atomic numbers above 10 can in principle be detected at once.

### *X-ray Diffraction (XRD)*

The XRD lab houses a BRUKER X-ray diffractometer for microstructural characterization of specimens. Information obtained from the diffractogram benefits a wide range of academic disciplines such as Chemistry, Polymers, Physics, Geology, Engineering, Electronics and Pharmaceutics.

### *Atomic Force Microscopy (AFM)*

The AFM imaging system, which has a lithography dedicated system, is capable of both nano-lithography and nano-manipulation in a humidity controlled ambient in virtually all three basic AFM imaging techniques, viz Tapping Mode, Contact Mode, and Non-Contact Mode.

### *Physical Properties Measurement System (PPMS)*

This system allows for the measurement of electrical, thermal, and magnetic properties at magnetic fields up to an optional 7, 9 or 16T, and accurately controlled temperatures in the range  $1.9 < T < 400\text{K}$ .

### *Accelerator Mass Spectrometry (AMS)*

The AMS facility provides a platform for rare isotope measurements such as  $^{14}\text{C}$ ,  $^{26}\text{Al}$  and  $^{10}\text{Be}$  that are all used in age dating in different contexts. The AMS facility at iThemba LABS is the only AMS facility on the African continent. Since it was commissioned it has been providing about 1000 dates annually. The impact on palaeoscience in South Africa is profound as more dates allow for fundamentally better science. Strategic

platforms such as the African Origins Program, that look to exploit scientific advantages offered by South Africa as a location, are being substantially enhanced by this platform.

### **Education and Training**

The IBA division offers high quality training to post-graduate students, thus ensuring that skilled capacity is created to fill the job market in Materials Sciences in South Africa. This include training of university students through lectures such the SAINTS program; supervision of research projects for honors, MSc and PhD students; internships, in-service training and short-term training through workshops, summer/winter schools and vacation programs.

### **International collaborations**

The research conducted within the IBA division for the past decades resulted in collaborations with local and international institutions including Instituut voor Kern- en Stralingsfysica in Belgium, Institut Pprime, CNRS, Université de Poitiers, in France, the Universidad Nacional de Colombia in Colombia, and the University of Saad Dahlab – Blida in Algeria.

### **Plans for the next 5 to 10 years**

Our plans for the next 5 to 10 years are to conduct research under the following four themes: 1: Diffusion kinetics studies; 2: Ion irradiation induced effects on the structure of matter; 3: Interaction and slowing-down of energetic ions in solids and 4: Biological and Environmental studies.

The following developments and upgrades will be implemented in the next five to ten years:

#### *Installation of a multifunctional scattering chamber ("Total IBA")*

IBA techniques will be combined in a single run to complement each other. The old approach of IBA analysis where RBS was mainly on offer in one beamline and PIXE in another is not suitable for Total IBA.

#### *Development of a dedicated beam-line for nuclear physics experiments*

This beamline will be an added capability for the sub-atomic physics community and specific physics will become available to be studied which is not possible with the Separated Sector Cyclotron facility.

#### *Development of a beamline dedicated to irradiation experiments*

One of the urgent problems of modern radiation physics and nuclear reactor materials science is the study of the effects of insoluble atomic impurities on the structure and properties of solids. Atoms of inert gases, in particular helium, arise and accumulate in materials as a result of neutron irradiation, being products of nuclear reactions.

#### *Development of an atmospheric (in-air PIXE) beam line*

A new beam line will be set-up to carry out IBA measurement in-air for cultural heritage studies in relevant Southern African archaeological materials to decipher the non-written history of indigenous communities that were living in the area more than 500 years ago.

## **Primary Category**

Accelerators

## **Secondary Category**

Condensed Matter & Materials Physics

## **Subgroup categories**

MaterialsPhysics—Materials for energy

## **Did you / will you submit this LOI to another category?**

NO

## **Additional Information**

NONE

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