



# Plan for Ion Beam Analysis Systems Based on 3-MV Tandem Accelerator



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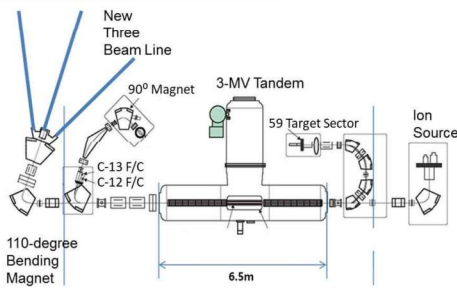
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## INTRODUCTION

The IBA (Ion Beam Analysis) techniques have been used for the material sciences and the needs and importance are continuously increased during last several tens of years from 1960's. The PIXE (Proton Induced X-ray Emission), ERDA (Elastic Recoil Detection Analysis), RBS (Rutherford Backscattering Spectroscopy), PIGE (Proton Induced Gamma-ray Emission), and NRA (Nuclear Reaction Analysis) are generally used IBA systems. For these IBA systems, usually MeV tandem accelerators are used and many worldwide accelerator laboratories which have these kinds of electrostatic accelerators are put their efforts to establish the IBA systems and performance improvements. [1-2] The KOMAC (Korea Multi-purpose Accelerator Complex) has two kinds of tandem accelerators, a 1.7-MV tandem accelerator (NEC; National Electrostatics Corp., USA) and a 3-MV tandem accelerator (HVEE; High Voltage Engineering Europa, Netherlands). Many kinds of IBA systems, a PIXE, an external beam PIXE, a RBS, and an ERD systems were established at the 1.7-MV tandem accelerator and has been operated from 2018. On the other hand, the 3-MV tandem accelerator had been used for the C-14 AMS (Accelerator Mass Spectrometry) before the movement to KOMAC. Reflecting the needs for the IBA, we make a plan to add three new beam lines, for ion implantations, ion beam analysis such as PIGE (Proton Induced Gamma Emission) and NRA, and beam irradiations for nuclear material test. And some material scientists want to know the composition of the thin film including contents of light elements such as hydrogen. So, we decided to make a plan to develop and install the combined IBA system, combination of RBS, PIXE, ERD, PIGE, and so on at the one beam line of the 3-MV tandem accelerator. Figure 1 shows the layout of the 3-MV tandem accelerator installed at the KOMAC.[3]

## 3-MV TANDEM ACCELERATOR

### 3-MV Tandem Accelerator & Beam Lines



### Specifications of the Accelerator

Company	HVEE	
Model No.	4130	
Terminal Voltage [MV]	0.2~3.0	
Ion Source	SNICS, Duoplasmatron	
Beam Currents [eμA]	Proton (1+)	25
	He (2+)	2

### Application Fields

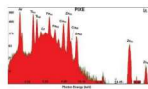
- AMS (Accelerator Mass Spectrometry)**
  - Carbon (C-14) dating
  - C-14 monitoring for the nuclear facility
- Irradiation**
  - Radiation damage test for nuclear material
  - Irradiation with high temperature
- IBA (Ion Beam Analysis)**
  - PIXE (Particle Induced X-ray Emission)
  - RBS (Rutherford Backscattering Spectrometry)
  - ERD (Elastic Recoil Detection)
  - PIGE (Proton Induced Gamma-ray Emission)
  - NRA (Nuclear Reaction Analysis), etc.

## COMBINED IBA SYSTEM

### Conceptual Design of Combined IBA Systems

#### PIXE

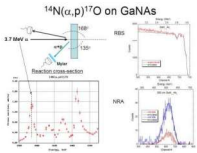
- To analyze multi-elements in the wide range thickness
- 2 X-ray detectors @ 45 degree
- Fast SDD (Silicon Drift Detector, AMPTEK) : < 10 keV
- Si(Li) or LEGe : > 10 keV
- For more compact system : CdTe detector
- PIXE using heavy ion beams



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#### RBS/NRA

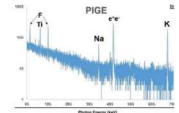
- To analyze the depth profile of the one or more elements in the thin layer
- 2 SSB detectors
- Scattering angle : 170° fixed, 30~170° variable
- Simultaneous analysis with ERD
- Goniometer : X, Y, Z motion control and incident angle



lbl.gov/rbs-lab/

#### PIGE

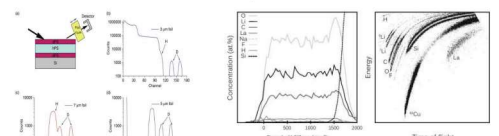
- HPGe detector or NaI(Tl) detector
- Angle : 90 degree to avoid or minimize the Doppler broadening effect



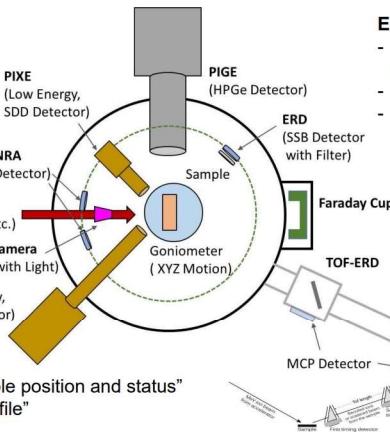
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#### ERD

- To analyze the lighter element compared to the incident ion beam (Hydrogen by He ion beam)
- SSB detector
- Filter to stop the recoiled and backscattered incident ion



Polymer Science: A Comprehensive Reference, 2012



#### Camera

- CCD camera with light
- For the monitoring of "the sample position and status" and "the beam position and profile"

#### ERD-TOF

- To analyze depth profile of the light element
- Incident ion beam : heavy ion beam (Cl, etc.)
- Length : > 1 m

## SUMMARY

We made a plan for the development of a combined IBA system based on the 3-MV tandem accelerator reflecting users' requirements and recent trends of IBA techniques for the advanced material science. The combined IBA system will improve the ability of the IBA and will be developed and installed at the 3-MV tandem accelerator in near future.

## REFERENCES

- [1] Stjepko Fazinic, "Utilization of the RBI Tandem Accelerator Facility for Analytical Applications", International Topical Meeting on Nuclear Research Applications and Utilization of Accelerators, Vienna, 4-8 May 2009
- [2] <https://www.surrey.ac.uk/ion-beam-centre>
- [3] Y. S. Cho, J. M. Ha, J. K. Suk, and K. R. Kim, "Conceptual Design of 110-degree Bending Magnet for 3-MV Tandem Accelerator Beam Line at KOMAC", Transactions of the Korean Nuclear Society Autumn Meeting, Gyeongju, Korea, October 26-27, 2017.

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