Workshop
on
Surface Modification by Ion Beams

Michigan Ion Beam Laboratory
University of Michigan
September 18, 2008

Background:

During the past decades, extensive experimentation on the use of ion beam techniques for surface modification has produced a novel generation of materials and applications. The modification of structures and properties, as well as the analysis of the modified surfaces are used today in a wide range of fields. They include amorphisation-recrystallisation studies, investigation of adhesion, hardness, wear resistance, corrosion, modification of interface properties by ion beam mixing, fabrication of semiconductor devices by low and high energy ion implantation, materials irradiation effects, etc. This technology is at the intersection of several scientific disciplines such as materials engineering accelerator physics, electrical engineering, and surface physics.

Workshop objectives:

- Present the basics of ion implantation (II), ion beam assisted deposition (IBAD) and accelerator based surface modification and analysis (ABSMA)
- Discuss current and potential applications of these techniques
- Review the experimental techniques and methodologies for II, IBAD and ABSMA used in the Michigan Ion Beam Laboratory
- Participate in hands-on laboratory applications in a workshop form

Who should attend:

This workshop is intended for undergraduate and graduate students and for researchers in the fields of materials sciences, chemistry, chemical engineering, physics, applied physics, nuclear engineering, electrical engineering and life sciences. It will be beneficial for all those who wish to learn about II, IBAD and ABSMA and to conduct and analyze experiments utilizing these techniques. It will also be beneficial for those already involved in surface modification.

8:30 am ***Registration***

9:00 am. ***Introduction and Welcome***
Gary Was, MIBL Director (UM NERS)
Dennis Grimard, Managing Director Michigan Nanofabrication Facility (MNF)
Sandrine Martin, Research Supervisor MNF

9:15 am. ***Ion Implantation*** Prof. Rachel Goldman (UM MSE):
Ion implantation (II) is a surface modification process in which ions are injected into the near-surface region of a solid substrate. High energy (10-400kV) ions are directed onto a surface. Typically, the impinging ions have kinetic energies 4-5 orders of magnitude greater than the substrate binding energy. Essentially any element can be injected into the near-surface region of any solid substrate. II has played a key role in the advancement of micorelectronics, providing both vertical and lateral control of dopant distributions. In this lecture, we describe the ion implantation process, including both novel and conventional ion beam formation methods. In addition, potential applications of ion implantation in optoelectronics, and other fields will be discussed.

10:00 am. ***Ion Beam Assisted Deposition*** Prof. Gary Was (MIBL)
IBAD is a combined process in which a film formed on a substrate is bombarded simultaneously with a directed beam of energetic ions. Ion energy, angle and ion-to-atom arrival rate ratio can be precisely controlled. Energetic ions can be used to modify film density, stress, texture, grain size, structure of the interface and other related properties. The role of coatings obtained by IBAD is significant in the advancement of technologies for applications in the electronics, optics, auto, aerospace and many other industries. This talk will cover the processes involved in IBAD and will provide examples and potential applications

10:45 am. ***Short Break***

11:00 am. ***Accelerator Based Surface Analysis Techniques*** Dr. Fabian Naab (MIBL).
Rutherford Back Scattering (RBS), Nuclear Reaction Analysis (NRA) and Forward Recoil Spectroscopy (FRS) are accelerator based techniques used to determine thin-film compositional analysis, crystal structures identification, an estimation of the number of defects and degree of disorder in crystalline specimens and many other properties without significantly affecting the target that is analyzed. The presentation will discuss the basic atomic and nuclear interaction between accelerated charged particles and the target; describe the experimental setup and the main physical processes and applications of the ion beam techniques employed at MIBL. A detailed theoretical analysis of a sample will be presented using RBS.

11:45 am ***Michigan Ion Beam Laboratory Instrumentation*** Dr. Ovidiu Toader (MIBL):
MIBL is a user friendly UM laboratory that is part of the Nuclear Engineering and Radiological Sciences. The presentation will include a detailed description and present the capabilities of the instruments available to the users in MIBL: the 1.7 MV tandem, particle accelerator, the 10-400 KV NEC ion implanter, the ion beam assisted deposition system (IBAD), the micro-hardness indenter, the Dektak profilometer and the vacuum furnace

12:30 Lunch
1:30 pm ***Lab Sessions (3 groups) – 3 hours***

Lab 1: Ion Implantation: 50 min

The NEC Ion Implanter (II) will be used. Participants will load samples in the chamber, will be shown the basic operation of the implanter, will assist in the setting up of the beam and will be taught how to decide the implant condition. They will implant Cr ions into a Si wafer that will be used in the surface analysis lab to confirm the implant dose and conditions. (Cr is a transition metal of interest in Spintronics, an emerging new technology that exploits the quantum spin states of electrons with various applications). Steps:

1. Stage presentation/capabilities and sample loading
2. Pumping out and presentation of the instruments in the stage area and on the beamline
3. Ion source presentation and ion source controls
4. Acceleration module presentation and voltage ramping
5. Beam on target and dose measurement
6. Venting the chamber and unloading of the samples

Lab 2: Surface analysis: 50 min

The participants will be introduced to the tandem accelerator operation mode, and will assist in the beam setup. They will be presented the surface analysis chamber and will load the samples obtained in the two other labs: from the ion implanter and from the IBAD system. The last part will include a presentation of the data acquisition system and an introduction to the simulation software used in the analysis. Steps:

1. Ion sources presentation
2. Accelerator outline, controls, working principles and applications
3. Chamber presentation and sample loading: the sample from implanter (Cr implanted Si) and the sample from the IBAD (the Si substrate with a layer of Cr on top).
4. Chamber under vacuum and presentation of the RBS instrumentation
5. Spectrum collection and principles of analysis (SimNRA)
6. High energy irradiations, stage and chamber presentation

Lab 3: Ion Beam Assisted Deposition (IBAD): 50 min

The IBAD system will be presented in detail and the instrumentation explained. The participants will load the substrates for deposition: a silicon wafer piece and a microscope slide. They will conduct the deposition of a Cr film, will learn how to control the deposition rate, the output of the ion source as well as the ion-to-atom ratio. Steps:

1. IBAD chamber presentation
2. Instrumentation – principles and controls
3. Sample loading and pumping
4. E-gun and ion source preparation
5. Deposition
6. E-gun and ion source shutdown and sample unloading

4:30 pm ***Wrap up:*** Gary Was, Ovidiu Toader, Dennis Grimard, Sandrine Martin

NOTE: More info at: http://www-ners.engin.umich.edu/research/Mibl/index.html