Experiment proposal at the IFIN-HH 3MV Tandetron ™ Accelerator, October 2017

Ion implantation dependency and electrical stability characterization of resistive switching materials.

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Aim of research: Our goal is to study the variations of electrical and magnetical resistive switching and surface resistivity in metal-TMO-metal devices in regard to stoichiometry and ion dopants implantation.

Resistive switching is the physical phenomenon that consists of sudden and non-volatile change of the resistance due to the application of electric stress, typically voltage, current pulsing or in some cases an external magnetic field. This effect is important in a series of future novel electronic devices, such as non-volatile random access memories, memristive electronic sensors with potentially new developments in dosimetry.

Curent experimental results : In 2017 a number of 24 multi-electrode samples were produced by magnetron sputtering deposition. The samples consisted of a thin layer of titanium dioxide TiO_2 with typical thickness of 60 nm to 85 nm tested by RBS at 3 MV Tandetron™ accelerator. The planar electrodes were composed of thin metal layers of Cu, Ti, Ag. Samples showed an initial electrode to electrode resistance ranging from 730 kΩ to 860 kΩ for Cu-Ag electrodes. Due to electrical formatting of the samples using 30 V for a maximum current of 300 mA samples showed a decrease in overall resistance to 35 kΩ for Cu-Ag electrodes.

Samples : We estimate 50 samples consisting from thin oxides (TiO2, IGZO) layers of 300-700 nm deposited on silicon substrate and glass and with different stoichiometry of oxygen varied through the deposition process. Two main methods of deposition will be used: magnetron sputtering deposition in IFIN-HH and electron plasma discharge deposition at National Institute of Materials Physics. Sample will have five different electrodes composed of Ag, Cu, Au, Al, Ti that will influence the characteristics of the resistive switching, different geometries will be tested.

Expected results and possible applications: The development of the memristor in 2012 led to an extensive search for possible applications. Due to the device properties to change its internal resistance in regard to total charge we expect that it can be used for the development of a new class of dosimeters and radiation detectors based on the memristive effect. Memristive devices properties to retain electrical parameters long after an external voltage was applied makes it suitable for non-volatile memories and electrical circuits capable of both processing and memory storage.

Experimental set-up: 3MV IFIN-HH Tandetron^{TM} accelerator.

Detectors:

- For RBS : Ortec charged particle Si-Au barrier detectors
- For PIXE : (X-ray detection): SDD x-ray detector placed in the reaction chamber.

Beam request at IFIN-HH 3MV Tandetron^{TM} accelerator

Experiment Title: Ion implantation dependency and electrical stability characterization of resistive switching materials.
Experiment by : Radu-Florin ANDREI
Short description of the scientific project (maximum four pages) : see above.
Beam time request: desired time 10 days in three different sessions:

- 2 days for PIXE-RBS prior to ion implantation
- 6 days for ion implantation
- 2 days for PIXE-RBS after ion implantation and electrical formatting.

Desired period: 5 May – 15 July.

Desired beam properties:

- Implantation: S, O, Nb, Ga as dopants with ion dose varied from 10^{12} to 10^{15} ions/cm^2 800-2000 MeV ions depending on sample thickness.
- RBS:He; Energy (MeV)* 2.5 - 3.5; Intensity*(p/nnA): ~ 25 nA
- PIXE:Type*: protons; Energy (MeV)* 2.7 - 3.3; Intensity*(p/nnA): ~ 10 nA

Special requirements for detectors, electronics, acquisition system:

- Experimental set-up belonging to the implantation reaction chamber IIB .
- Experimental set-up belonging to the PIXE-PIGE-RBS reaction chamber using amptek SDD X-ray detector inserted.

Minimal information needed for the radiological risk evaluation:

- Estimate of the residual activity as a result of irradiation* : - 0 Bq
- Means of storage/transportation for irradiated targets* : - No special means needed