Course: ***Fundamental aspects of reactive magnetron sputtering***

Course Objectives

- Understand the fundamental processes driving (reactive) magnetron sputtering
- Develop strategies for dedicated experiments to unravel the complexity of reactive magnetron sputtering
- To get a good overview of the current literature and modelling techniques.

Course Description

Reactive magnetron sputter deposition is a mature technique often used in laboratories and at industrial level to grow compound thin films. The growth of these films is defined by the deposition conditions, and therefore a good knowledge of the deposition process is essential to tune the growth and as such the film properties.
After a short introduction on the physics of sputtering, the magnetron discharge and the transport of sputtered atoms through the gas phase, the course starts with a few definitions regarding reactive sputtering to show that the processes driving this technique are general applicable. This introduction assist the attendee to the next step : the description of the most common experiment during reactive magnetron sputtering, the hysteresis experiment. The simplicity of this experiment fools initially the scientist because it hides a complex interplay between different processes at the target, in the plasma and, at the substrate defines the actual outcome of the experiment. During the course the details of this experiment are analyzed, and modelling is used to introduce the attendee in the different processes. In this way, the attendee will gain knowledge in a welth of important process controlling thin film growth such as reactive ion implantation, chemisorption, preferential sputtering, deposition profile, discharge voltage behaviour. A good knowledge of these processes will arm the attendee to analyze and to control the reactive sputtering process.

Course Content

Chapter 1. Sputter deposition
- Sputtering : ion solid interaction, sputter yield
- Secondary electron emission
- The magnetron discharge

Chapter 2. Definitions
Chapter 3. A first experiment
- Key aspects of reactive magnetron sputtering
- Target poisoning

Chapter 4. A first model
- The Berg model : gas balance equations
- Feedback control
- Process stability

Chapter 5. Important process parameters
- The discharge power
- The deposition profile : influence of the deposition geometry
- The magnetic field : the racetrack

Chapter 6. More complex conditions
- Dual reactive sputtering : two sources, one reactive gas

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- Mixed reactive gasses : oxynitrides
- Reactive sputtering from an alloy target

Chapter 7. Dynamics of reactive sputtering

- Feedback control again
- Gas pulsing

Chapter 8. A second series of experiments

- Target sputter cleaning : balance between oxide formation and removal
- Influence of the argon pressure
- Influence of the pumping speed

Chapter 9. Improving the model

- Ion beam experiments
- Reactive ion implantation
- Knock on implantation
- Fitting an experiment
- New questions and some answers

Chapter 10. Discharge voltage behaviour during reactive sputtering

- Secondary electron emission : relationship between electronic properties and electron emission
- Preferential sputtering
- Predicting the discharge voltage behaviour during reactive sputtering
- Negative ion emission : origin, and influence on the thin film properties

Chapter 11. Influence of redeposition on the target : rotating cylindrical magnetrons

- Rotating cylindrical magentrons
- Influence of the rotating speed on the hysteresis

Chapter 12. The influence of the deposition regime on the thin film growth

- Structure zone models : origin and correlation with the deposition parameters
- Energy flux measurements : the concept of the available energy per arriving atom
- Examples of structure zone models : TiN, ZnO.