Linköpings universitet
TEKNISKA HÖGSKOLAN

Course: Fundamental aspects of reactive magnetron sputtering

Given by Professor Diederik Depla, Ghent University, Belgium

Time:
Wednesday 13.15-17.00, Thursday 8.15-12.00, December 11-12, 2013.
An evening event is planned with Belgian beer and light food.

Location/Room:
Wednesday: Planck, Fysikhuset, Linköping University, Linköping.
Thursday: to be decided, Linköping.

Who Should Attend?
PhD-students, scientists, engineers and technicians involved in deposition, characterization, or manufacturing/marketing of thin film equipment for reactive magnetron deposition.

The course is primarily a PhD-course for students at IFM, Linköping University (2 hp), but is also open for members of the Swedish Vacuum Society. To register as a new member in the society, please go to: svs.mawik.se/Register

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 modeling 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 modeling is used to introduce the attendee in the different processes. In this way, the attendee will gain knowledge in a wealth of important process controlling thin film growth such as reactive ion implantation, chemisorption, preferential sputtering, deposition profile, and discharge voltage behavior. 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
- 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 behavior during reactive sputtering
- Secondary electron emission: relationship between electronic properties and electron emission
- Preferential sputtering
- Predicting the discharge voltage behavior 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.

Instructor:
Prof. Diederik Depla
Department of Solid State Sciences, Ghent University, Belgium
www.draft.ugent.be

Prof. Depla has received his Master Degree in Chemistry in 1991 at Ghent University (Belgium). In 1996 he promoted with a PhD thesis in Solid State Chemistry on spray drying of precursors for superconductors. After a short period as senior scientist in the Department of Solid State Sciences, he became in 1999 Professor at the Department for Solid State Sciences where his research focused on the fundamental aspects of reactive magnetron sputtering. He has shown the importance of ion implantation in the description of the reactive magnetron sputter process. In this way, his continuous research in this area resulted in several publications. He is now head of the research group "Design, Research And Feasibility of Thin films (DRAFT)" in the same department. This research group continues on further unraveling the reactive sputter process, and on applying this technique for the deposition of complex oxide materials. The key feature of DRAFT is a thorough analysis of the deposition process by different techniques to link film properties to the fundamental aspects of thin film growth.

Course Materials:

- A printed copy of the slides will be provided.
- A book "Magnetrons, reactive gases and sputtering" by D. Depla, ISBN 978-1-304-34781-7 will be offered to a reduced price (estimated to 300 kr).

Register

The number of participants is limited (approximately 50-80, depending on available lecture room). For PhD-students at IFM the course is free of charge. For member of the Swedish Vacuum Society a fee of 2500 kr will be invoiced from the society. The fee will include one copy of the slides, coffee breaks and evening event.

Conference registration is done with Therese Dannetun, therese.dannetun@liu.se, 013-28 29 44. You will receive a confirmation.

Please send:

1. Name
2. Univ./Company
3. Email
4. PhD-student or not
5. Social security number (only for PhD-students, that like to have credit points)
6. Invoice address (not PhD-students at IFM, LiU)
7. Ordering the book: Magnetrons, reactive gases and sputtering" (yes or no)

Accommodation

Guest of Linköping University can claim reduced price at the following hotels (agreement no. LiU-2013-00519):

Hotel	**Price for single room – excl. moms**	**www**
First Hotel	934	www.firsthotels.se/linkoping
Park Hotel	775	www.fawltytowers.se
Hotell du Nord	728	www.hotelldunord.se
Scandic Frimis	929	www.scandichotels.se/frimurarehotellet
Scandic Linköping Väst	920	www.scandichotels.se/linkopingvast