NORMANDALE COMMUNITY COLLEGE
COMMON COURSE OUTLINE
VACT 2297 and NANO 2297, Thin Films Deposition

I. EFFECTIVE DATE OF OUTLINE

Fall Semester, 2012. To be reviewed by the department annually.

II. CATALOG DESCRIPTION

A. VACT 2297 and NANO 2297
B. Thin Films Deposition
C. 3 Credits
D. Offered Spring Semester
E. Prerequisites: VACT 2293
F. Thin films deposition refers to techniques used to deposit layers of material on a surface ranging in layer thickness of a few nanometers (1×10^{-9} m) up to a thickness of 1 micrometer (1×10^{-6} m). This course provides an overview of the methods and the embedded vacuum-based technologies used to realize various material deposition processes. Students set up and run processes such as vacuum evaporation and sputtering to create thin films and then examine characteristics of the layer produced.

III. RECOMMENDED ENTRY SKILLS/KNOWLEDGE

Students are expected to possess intermediate knowledge and skills related to the composition, functions and operation of vacuum-based systems (completion of VACT 2293 or NANO 2293) commensurate with a readiness for this second-year, post-secondary level course. Students should possess intermediate skills in the use of the following Microsoft Office applications: Word and Excel. Examples of intermediate skills in the use of these software applications are creating mathematical functions to analyze data, creating appropriate charts to represent tabled data, adding a chart to a lab report and creating a report according to stated layout criteria. Students should be familiar with the college online course site and be prepared to use the online site to access information about the class including downloads of file-type information, post homework and interact with the instructor and class peers through the online site. Students should also have an intermediate knowledge of how to perform searches for information on the Internet.

IV. OUTLINE OF MAJOR CONTENT AREAS

A. Defining thin films deposition by layer thickness produced, techniques and applications
B. Safety considerations and practices
C. Basic physics and chemistry behind thin films layer formation
D. Thin films characteristics and associated techniques of evaluation and measurement
   a. Topography – Scanning Electron Microscopy
   b. Film thickness and roughness – Stylus Profilometry
   c. Structure integrity – X-ray Diffraction
   d. Resistance – 4-point probe
   e. Optical properties – Ellipsometry
E. Deposition techniques
   a. Physical deposition
      1) Vacuum evaporation
      2) Molecular Beam Epitaxy
      3) Sputtering
      4) Cathodic Arc Vaporization
   b. Chemical deposition
      1) Chemical Vapor Deposition
      2) Plasma Assisted Chemical Vapor Deposition
F. Dry Etching Techniques
   a. Plasma
   b. Sputter
   c. Reactive-ion

V. LEARNING OUTCOMES

Upon successful completion of VACT 2297 or NANO 2297, students will have demonstrated ability to:

A. Classify a thin film layer by the thickness criterion.
B. Identify applications for which thin films deposition processes are essential to realizing certain performance features of the end product.
C. Differentiate the two broad categories of deposition techniques (physical deposition and chemical deposition) by comparing and contrasting the essential mechanisms of the deposition process as well as the outcomes of the process.
D. Identify workplace hazards associated with running thin films deposition processes and for those hazards describe corresponding safety practices and techniques to use when handling, operating and maintaining related equipment and materials.
E. Describe the essential steps in realizing the formation of a thin film on a substrate.
F. Classify the physical reaction type and resulting layer formation process according to the energy requirements associated with the process.
G. Identify basic characteristics which qualitatively and quantitatively define a thin film layer and the associated methods for measuring these characteristics.
H. Describe the process steps and the key process inputs associated with deposition by vacuum evaporation and determine process variables such as evaporation rate and mass flux for given process inputs.
I. Identify Molecular Beam Epitaxy (MBE) as a special form of vacuum evaporation conducted under ultra-high vacuum conditions and compare and contrast characteristics of the MBE process and the thin layer formed with thin layers formed by more general vacuum evaporation techniques.
J. Describe the process steps and the key process inputs associated with deposition by sputtering, determine process variables such as maximum energy transfer to target atom and sputter yield for given process inputs, and identify basic types of sputtering deposition techniques.
K. Describe the process steps and the key process inputs associated with deposition by cathodic arc vaporization.
L. Describe the process steps and the key process inputs associated with deposition by chemical vapor deposition (CVD) and determine process variables such as maximum flux at substrate and growth rate for given process inputs.
M. Identify Plasma Assisted Chemical Vapor Deposition (PACVD) as a special form of CVD under plasma conditions and compare and contrast characteristics of the PACVD process and the resulting thin layer formed with thin layers formed by more general CVD techniques.
N. List the basic mechanisms in realizing the dry etch process on a thin film layer.
O. Classify the types of dry etch processes according to critical process input parameters and match those inputs to equipment needs.
P. Compare and contrast the process of dry etching to the deposition processes reviewed.
Q. Select materials, set up equipment and execute basic thin films deposition processes in the context of lab activities.
R. Perform measurements of basic thin films characteristics in the context of lab activities.
S. Practice appropriate safety techniques and procedures when performing lab activities.
T. Create advanced lab reports which convey information about lab activities including the purpose and objective, background reference, procedure, summary of results, analysis, conclusion and appendix of data tables and graphs.

VI. METHODS USED FOR EVALUATION OF STUDENT LEARNING

Students will be evaluated on the following categories of course work: (1) assignment work involving both written descriptive answers and mathematical based problem solving; (2) lab reports; (3) demonstration of laboratory competence including but not limited to practices in (a) safety, (b) equipment operation, (c) collecting and documenting data, (d) troubleshooting and analysis techniques, (e) maintaining a lab notebook; and (4) mid-term and final end-of-course exams.

The final grade will be determined by some appropriate weighting of the course assignments, lab work and exam results.

VII. SPECIAL INFORMATION

A. Students will need access to a model vacuum-based system to conduct a variety of lab activities. The vacuum-based system will be available for student use in the classroom.
B. Students will need access to equipment to perform thin film characterization measurements as part of lab activities. The measurement equipment will be available for student use in the classroom.
C. Students will need access to appropriate safety gear. The safety gear will be available for student use in the classroom.