**Course number and name: MTSE 3010: Bonding and Structure**

**Credits and contact hours:** 3 Credits. Office Hours: Wednesday 2 PM - 4 PM

**Instructor’s or course coordinator’s name**: Dr. Thomas Scharf

**Text book, title, author, and year**

The Structure of Materials - An Introduction to Crystallography, Diffraction & Symmetry, by Marc De Graef & Michael McHenry, 2nd edition, Cambridge University Press, 2012.

1. *Other supplemental materials*

Structure and Bonding in Crystalline Materials

By Gregory S. Rohrer, Cambridge University Press

**Specific Course Information**

1. *Brief description of the content of the course (catalog description)*

Amorphous and crystalline structures in metals, ceramics and polymers, point defects in crystals, structure determination by X-ray diffraction.

1. *Prerequisites or co-requisites*

MTSE 3000, 3001

1. *Indicate whether a required, elective, or selected elective course in the program*

Required

**Specific goals for the course**

*a. Specific outcomes of instruction*

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| **Specific Course Learning Outcome** |
| 1. Understand the differences in atomic bonding and crystal structures for all material classes. |
| 2. Analyze material structure across multiple size and length scales. |
| 3. Recognize how material bonding and structure determines material properties. |
| 4. Understand the importance of crystallography and crystal symmetry and how it relates to materials structure.  |
| 5. Apply the concepts of x-ray diffraction as a materials characterization technique to determine crystal structures. |

1. *Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes that are addressed by the course.*

This course addresses ABET Student Outcome 7

**Brief list of topics to be covered**

I. Electronic and Atomic Structure and Bonding

Review of Simple Bonding Models

Periodic Trends & Bonding Force/Energy

Lennard-Jones Model

Born-Mayer-Huggins Model

II. Crystal Structure

Crystal Lattice & Unit Cells

Metallic Crystal Structures

Ceramic Crystal Structures

Interstitial Compounds

III. Crystallography

Introduction to Crystallography

2-D & 3-D Bravais Lattices

Primitive and Basis Vectors in Crystal Structures

Basic Symmetry Operations

2-D Point & Plane Groups

3-D Point Groups

Neumann’s Law and Tensor Properties

3-D Space Groups

3-D Symmetry Elements in Crystalline Materials

Relationships between planes and directions

IV. X-ray Diffraction - XRD

Introduction to XRD & Indexing Crystal Systems

Structure Factors

XRD Intensity Calculations

Texture Determination and Pole Figures

Stereographic Projection and Texture/Anisotropy

V. Structure of Non-crystalline (amorphous) Solids

Introduction to non-crystalline materials

Bernal Model

Medium-range ordering

Radial distribution function