

# MSE3111: CERAMIC MATERIALS

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## Effective Term

Semester A 2024/25

## Part I Course Overview

### Course Title

Ceramic Materials

### Subject Code

MSE - Materials Science and Engineering

### Course Number

3111

### Academic Unit

Materials Science and Engineering (MSE)

### College/School

College of Engineering (EG)

### Course Duration

One Semester

### Credit Units

3

### Level

B1, B2, B3, B4 - Bachelor's Degree

### Medium of Instruction

English

### Medium of Assessment

English

### Prerequisites

AP2102/ MSE2102 Introduction to Materials Engineering

### Precursors

Nil

### Equivalent Courses

AP3111 Ceramic Processing and Microstructure Development

### Exclusive Courses

Nil

## Part II Course Details

### Abstract

This course aims to provide students with fundamental knowledge of the structure and properties of ceramic materials and introduction of processing routes for engineering ceramics, with an emphasis on processing-structure-property

relationships. Students will gain knowledge of bonding, crystal structure, microstructural defects in ceramics and they are correlated with processing methodologies. Students will have a hands-on experience in the fabrication of advanced ceramic samples using mixed oxide and learn to organize the lab results into a logical and concise report. Students will also practice reading and critical thinking on technical article on the field.

### Course Intended Learning Outcomes (CILOs)

| CILOs |  | Weighting (if app.) | DEC-A1 | DEC-A2 | DEC-A3 |
|-------|--|---------------------|--------|--------|--------|
| 1     | Describe the bonding type and crystal structure of ceramic materials.  | 20                  | x      | x      |        |
| 2     | Explain microstructural defects at different length scales in ceramics.  | 20                  | x      | x      |        |
| 3     | Discuss mechanical, thermal and electrical properties of ceramics and their correlation with defects.  | 20                  |        | x      | x      |
| 4     | Explain the working principle of and microstructure evolution during sintering. Familiarize classical processing methodologies for engineering ceramics. | 20                  |        | x      | x      |
| 5     | Discuss the linkage between processing, structure and properties of ceramics.  | 20                  |        | x      | x      |

#### A1: Attitude

Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

#### A2: Ability

Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

#### A3: Accomplishments

Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

### Learning and Teaching Activities (LTAs)

| LTAs | Brief Description | CILO No.   | Hours/week (if applicable) |         |
|------|-------------------|--|----------------------------|---------|
| 1    | Lectures          | Students will engage in lecture activities covering key concepts, such as fundamental knowledge of structure, defect, properties and basic principles of processing of ceramic materials | 1, 2, 3, 4, 5              | 3hrs/wk |
| 2    | Tutorials         | Students will critically engage in interactive discussion and learning to apply basic principles to difficult homework and quiz problems.  | 1, 2, 3, 4, 5              | 1hr/wk  |

|   |            |   |               |         |
|---|------------|---|---------------|---------|
| 3 | Laboratory | Students will have a hand-on experience in the fabrication of advanced ceramic samples using mixed oxide processing and learn to organize the lab results into a logic and concise report | 1, 2, 3, 4, 5 | 3hrs/wk |
|---|------------|---|---------------|---------|

**Assessment Tasks / Activities (ATs)**

|   | ATs                 | CILO No.      | Weighting (%) | Remarks (e.g. Parameter for GenAI use) |
|---|---------------------|---------------|---------------|--|
| 1 | Homeworks, quizzes  | 1, 2, 3, 4, 5 | 15            |  |
| 2 | Lab reports         | 2, 4, 5       | 15            |  |
| 3 | Course presentation | 4, 5          | 5             |  |
| 4 | Midterm exam        | 1, 2, 3, 4    | 15            |  |
| 5 | Final Exam          | 1, 2, 3, 4, 5 |               |  |

**Continuous Assessment (%)**

50

**Examination (%)**

50

**Examination Duration (Hours)**

2

**Additional Information for ATs**

For a student to pass the course, at least 30% of the maximum mark for the examination must be obtained.

**Assessment Rubrics (AR)****Assessment Task**

1. Assignments, quizzes, midterm test

**Criterion**

Capability of explaining and applying basic principles and working knowledge of processing of ceramic materials and microstructure development

**Excellent (A+, A, A-)**

High

**Good (B+, B, B-)**

Significant

**Fair (C+, C, C-)**

Moderate

**Marginal (D)**

Basic

**Failure (F)**

Not even reaching marginal levels

**Assessment Task**

2. Lab reports

**Criterion**

Ability to identify and explain processing-structure-property relationships

**Excellent (A+, A, A-)**

High

**Good (B+, B, B-)**

Significant

**Fair (C+, C, C-)**

Moderate

**Marginal (D)**

Basic

**Failure (F)**

Not even reaching marginal levels

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**Assessment Task**

3. Course presentation

**Criterion**

Ability to read, analyze and present technical contents with critical thinking on the field

**Excellent (A+, A, A-)**

High

**Good (B+, B, B-)**

Significant

**Fair (C+, C, C-)**

Moderate

**Marginal (D)**

Basic

**Failure (F)**

Not even reaching marginal levels

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**Assessment Task**

4. Examination

**Criterion**

Combination of assessment task 1 and 2

**Excellent (A+, A, A-)**

High

**Good (B+, B, B-)**

Significant

**Fair (C+, C, C-)**

Moderate

**Marginal (D)**

Basic

**Failure (F)**

Not even reaching marginal levels

## Part III Other Information

### Keyword Syllabus

- Introduction to course
  - Course objectives
  - Important definitions
  - Overview of processing-structure-property relationship
  - Structure of ceramics
- Bonding type and crystal structure of ceramics
- Structural defects in ceramics
- Properties of ceramics
- Powder synthesis and forming technologies for engineering ceramics
- Sintering science and microstructure evolution
- Characterization for ceramic materials
- Processing-structure-property relations in ceramics

### Reading List

#### Compulsory Readings

| Title |  |
|-------|--|
| 1     | “Fundamentals of Ceramics” by M.W. Barsoum, 2003 ISBN: 0750309024  |
| 2     | “Formation of BaTiO <sub>3</sub> from BaCO <sub>3</sub> and TiO <sub>2</sub> in air and in CO <sub>2</sub> ” J. Am. Ceram. Soc. (1959) 42, 212-216 |
| 3     | “Chemical processing and properties of nanocrystalline BaTiO <sub>3</sub> ” Mat. Res. Soc. Symp. Proc. (1992) 271, 339-344                         |
| 4     | “Barium Titanate piezoelectric ceramics manufactured by two-step sintering” Jpn. J. Appl. Phys. (2007) 46, 7035                                    |

#### Additional Readings

| Title |   |
|-------|---|
| 1     | M N Rahaman, “Ceramic Processing and Sintering” , Marcel Dekker (2003) TP807.R28 2003   |
| 2     | W D Kingery, HK Bowen and D R Uhlmann, “Introduction to Ceramics” , John Wiley & Sons, Inc. (1976) TP807.K52 1976                   |
| 3     | T A Ring, “Fundamentals of Ceramic Powder Processing and Synthesis” , Academic Press (1996). TP815.R56 1996                         |
| 4     | J S Reed, “Principles of Ceramic Processing” , Wiley Inter-Science (1995) TP807.R36 1995  |
| 5     | A P Tomsia and A M Glaeser (Ed.), “Ceramic Microstructures: control at the atomic level” , Plenum Press (1998). TA455.C43 C464 1998 |
| 6     | C. Barry Carter and M. Grant Norton, “Ceramic Materials” , e-book 2013  |

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| 7 | W.D. Callister, D.G. Rethwisch, “Materials Science and Engineering: An Introduction” , 8th edition, W.D. Callister, D.G. Rethwisch, 2009 |
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