MSE 420 CERAMIC MATERIALS AND PROPERTIES

Spring 2026
3 hours or 1 unit
Prof. Waltraud M. (Trudy) Kriven, 105 MSEB Building, kriven@illinois.edu
Tues and Thurs, 11 am – 12.20 pm,
Room 305 Materials Science and Engineering Building

Exams
Mid term I – 1 hour 40 mins exam
Mid term II – 1 hour 40 mins exam
Final – 3 hour exam TBD

Grading
Mid Term I 20 %
Mid term II 20%
Homework – 15%
Final – 45 %

80-86% A^-, 87-93% A, > 94% A^+
65-69% B^-, 70-75% B, 76-79% B^+
50-54% C^-, 55-59% C, 60-64% C^+

Textbook:

- Y. M. Chiang, D. Birnie III and W. D. Kingery, "Physical Ceramics", John Wiley and Sons (1997)

Reference Books:

- W. D. Kingery, H. K. Bowen, D. R. Uhlmann, " Introduction to Ceramics" 2nd Edition, John Wiley and Sons, (1976)
- D. W. Richerson, "Modern Ceramic Engineering", 3rd edition, (2006), Taylor and Francis
- C. Barry Carter and M. Grant Norton, "Ceramic Materials," (2007)
- Robert E. Newnham, "Properties of Materials," Oxford University Press (2005)
- David J. Green, "An Introduction to the Mechanical Properties of Ceramics," Cambridge University Press (1998)
- C. G. Gergeron and S. H. Risbud, "Introduction to Phase Equilibria in Ceramics." Published by the American Ceramic Society (1984)
- "Principles of Phase Diagrams in Materials Systems", by P. Gordon and published by McGraw-Hill (1968)
- G. W. Brindley and G. Brown, "Crystal Structures of Clay Minerals and Their X-Ray Identification," Published by the Mineralogical Society UK, (1980).

Catalogue Description, Pre-requisites and Schedule

Basic principles and understanding of structure-property relations in ceramic materials. Examples will be drawn from both traditional and advanced ceramics. Knowledge of structure on multiple length scales (including atomic, grain boundary and grain structure, as well as the structure of clays and amorphous materials) and several properties (including electrical, magnetic, mechanical and thermal) will be gained. *Prerequisite:* MSE 182 or 200. *3 hours or 1 unit.* 3 lecture-discussion hours/week.

Course Topics

1. Atomic structure, including ionic and covalent bonding, ceramic crystal structures, clay structures and amorphous materials (network formers, modifiers and intermediate oxides).
2. Atomic defects, including intrinsic and extrinsic point defects, Kröger-Vink notation, defect reaction equilibria
3. Electrical properties, including dielectrics, piezoelectrics, ferroelectrics
4. Magnetic properties, including ferromagnetic materials
5. Microstructure development, including solid-state sintering, densification versus coarsening processes, grain boundary mobilitiy, porosity evolution (stability/entrapment) viscous densification, liquid-phase sintering, constrained sintering
6. Thermal properties including heat capacity, thermal conductivity, thermal expansion, creep and thermal stresses
7. Mechanical properties including strength, toughness and microstructural design

Course Objectives:

1. Develop and understanding of the structure of ceramic materials on multiple length scales
2. Develop knowledge of point defect generation in ceramic materials and their impact on transport properties
3. Develop knowledge of electrical properties including examples of ceramic applications in which behavior is governed by materials structure over varying length scales
4. Develop understanding of the magnetic, thermal and mechanical properties of ceramics

Course Outcomes:

1. Knowledge of the crystal structures of a wide range of ceramic materials
2. Knowledge of the structure of clays, minerals and glasses
3. Given a ceramic component, be able to calculate its intrinsic and extrinsic defect populations
4. Design a suitable sintering schedule for heat-treating ceramic and understand the effects of existing microstructural features (e.g. porosity, impurities, etc.) on microstructural evolution during this process
5. Knowledge of properties of ceramics and their structural origin
6. Familiarization with a wide array of characterization techniques

Assessment Tools:

1. Homework problems focused on ceramic structure, properties, ternary phase equilibria and relations between these two topics
2. Two written midterm exams designed to test the student's ability to understand the subject matter and to apply his/her knowledge
3. One comprehensive final exam designed to test the student's ability to understand the subject matter and to apply his/her knowledge

Contribution of Course to Meeting the Professional Component: 100%