

Modern Ceramics Materials

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Ceramics engineering is to design and manufacture components of inorganic nonmetallic materials which mainly starts from solid articles. A series of lectures involves a comprehensive treatment of the structure-property relationships of ceramic materials for students with a background in materials science and engineering. Topics include: crystal structures of ceramics and their effect on physical and chemical properties, the structure and properties of oxide glasses and glass ceramics, defects and transport properties in ceramics materials. Here is the content of 5 lectures on modern ceramics materials.

Main text: C. Barry Carter, M. Grant Norton, "Ceramic Materials," Springer (2013).

Week 1. Crystal Structures of Ceramics

- Structural differences between ceramics, metals and polymers
- Simple fcc structures: Rocksalt, Fluorite and zinc blende
- Simple hcp structures: Wurtzite, Corundum, Rutile
- 1D and 2D crystalline silicates

Week 2. Structure Related Properties of Ceramics

- complex crystal such as perovskite, spinel and 2-dimensional silicates (e.g. micas, clays and other layer minerals).
- the structure and processing of glasses
- introduction to glasses with a focus on structural similarities and differences between crystalline silicates and glasses

Week 3. F Properties of Ceramics and Defects in Ceramics

- ionic, electronic, and space charge polarizations in ceramics
- difference between dielectric and piezoelectricity
- examples of device application
- origin of dielectric properties
- ferroelectricity in perovskite structure materials
- ferrimagnetism and antiferromagnetism in spinels
- domain structure and its response to external magnetic field
- examples of device application

Week 4. Defects in Ceramics

- origin of point defects
- thermodynamics of point defects
- electronic defects
- ionic defects: stoichiometry and defect equilibria
- defect concentration vs temperature (oxygen partial pressure)

Week 5. Defect Related Properties

- electrical conductivity in ceramics

- ionic conductivity in oxides, application to oxygen sensors
- heat transfer in ceramics and its application to design of electrical packaging and refractories.
- diffusion of atoms ceramics, which is determined by the defect structure
- correlation between defect diagram and ionic/electrical conductivity in ceramics
- use of diffusion phenomena for energy application