MatSE 469: Ceramics Laboratory IV

Course Designation: Formerly designated CerSE 464; this is a required course in Ceramic Science and Engineering, and an elective course for other options

Catalog Description: Measurement of electrical, magnetic, optical, and thermal properties of ceramics

Course Description: (Extended description required by Penn State's Faculty Senate for inclusion on the course website)

This course is intended to familiarize the student with the electrical, magnetic, optical and thermal properties of ceramics with a series of demonstrations/experiments, in which hands-on experience will be gained.

Students interested in disciplines such as metallurgy, ceramic science, electronic and photonic materials, mechanical engineering, aerospace engineering, industrial engineering, engineering science, and chemical engineering will benefit significantly from this course.

The course is offered annually, in the spring semester, in the Department of Materials Science and Engineering.

Prerequisites: MatSE 468 (formerly CerSE 463)

Textbook: Lab Manual

Course Objectives: The objectives of the course shall be to enable students to:

1. Apply principles of mathematics, chemistry, and physics to understanding the fundamental phenomena contributing to the thermal, electrical, and optical properties of materials.

2. Apply methods for the quantitative characterization of melting point, crystalline phase identification, solid state reactions, temperature, thermal expansion, thermal diffusivity, refractive index, electrical resistivity, dielectric constant, dielectric strength and hysteresis, piezoelectric effect.

3. Understand the interrelationship between processing, structure, properties, and performance of materials in thermal, optical and electric applications

4. Critically interrogate the value and validity of materials property data in the selection of, and design with materials for thermal, optical, and electrical applications

Topics Covered:

1. Scientific methodology and technical reporting
2. Electrical resistance and conductance
3. Capacitance, loss factor, and dielectric properties of $BaTiO_3$ based materials
4. Dielectric hysteresis
5. Dielectric strength
6. Piezoelectricity
7. Refractive indices of crystals and glasses
8. Thermal expansion
9. Thermal conductivity
10. Melting point determination
11. Solid state phase transitions in ceramic systems

Class Schedule: 1 credit course offered annually meeting once per week for 3 hours

Course Outcomes: Upon completion of the course, the student shall be able to:

1. Perform direct measurements of melting point using hot stage microscopy
2. Measure index of refraction using oil immersion and divided-circle spectrometric techniques
3. Measure the high temperature electrical resistivity of materials using two- and four-point DC resistivity techniques
4. Characterize the evolution of phases during the synthesis and decomposition of a binary ceramic oxide using powder x-ray diffractometry
5. Characterize extent of solid solubility using precision lattice parameter techniques
6. Measure the dielectric constant, loss tangent, Curie Weiss constant and Curie Transition Temperature for ferroelectric ceramics using capacitance measurements.
7. Characterize the thermal expansivity of ceramics suing high temperature dilatometry; exercise mixture rules to rationalize the thermal expansivity of composite ceramics.
8. Measure the dielectric strength and breakdown behavior in polymers and ceramics
9. Measure the thermal diffusivity of ceramics using Angstrom's method during transient heating
10. Determine the hysteretic behavior in linear and non-linear dielectrics
11. Measure the electrooptic effect in single crystal lithium niobate using cross polarizers and He-Ne irradiation

Assessment Tools:

- Laboratory notebook, instructor observations of laboratory technique, and short, informal reports on eight experiments
- Two full length formal reports

Professional Component: The course topics address the selection of characterization methods, and the requisite skills necessary to quantify the thermal, electrical, and optical properties of ceramics. Emphasis is placed on integrating the student's background in crystal chemistry, physics, thermodynamics, kinetics and elastic/mechanical properties to the interpretation of experimental data obtained in the laboratory. Students collect their data using standard industrial practices, with an strong emphasis on proper use of laboratory notebooks, and are required present their results and interpretations in professional-quality reports.

Prepared by: John R. Hellmann, February 2002

MAP TO DEPARTMENTAL OUTCOMES (For further detail, see coursebook)											
a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**
1	1	1	1	2	2	1	3	3	3	1	1

MAP TO DEPARTMENTAL OBJECTIVES (For further detail, see coursebook)						
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
1,2,3,4	1,2,3,4	1,2,3,4	4	2,4	1,2,3,4	4