Department of Materials Science and Engineering
University of Maryland

ENMA 424: Manufacturing Ceramics (Elective)- 3 Credits

Class Schedule:

Mon. 11:00-11:50 am	(typically lecture)
Weds. 9:00-10:50 am	(labs, tours, discussion)
Weds. 11:00-11:50 am	(lecture or labs, tours, etc.)

Instructor: Dr. Isabel Lloyd

Textbook: There is no single textbook that covers all the material at an appropriate level. Selected readings will be placed on course reserve in the Engineering and Physical Sciences Library.

Catalog/Course Description: Relationships between properties and manufacturing, effect of manufacturing process on product cost, case studies of modern ceramics like electronic packaging, high temperature bearings. Laboratories and field trips will supplement the lectures.

Pre-requisites: ENMA 300 is desirable.

Course Goals: The purpose of this class is to introduce manufacturing (as opposed to processing) of advanced ceramic products and systems. Emphasis is placed on identifying and understanding the critical steps, processes and/or behaviors and then designing appropriate processes and products. Students satisfactorily completing the class will:

1. Be familiar with current manufacturing practice for several advanced ceramic products or systems. They will understand how individual processing techniques fit into the overall manufacturing process and how they affect product performance and cost.
2. They will be broadly familiar with plant layout and design as a result of plant tours and class discussion.
3. Understand the concepts behind designing for reliability, flexible manufacturing and intelligent manufacturing.
4. Be able to identify and evaluate potential critical aspects of the manufacturing process or product design for a particular product.
5. Be able to apply concepts they have learned in the class (from lectures, laboratories, plant tours, discussions and their projects) in new contexts.
6. Be able to evaluate a product or process in terms of its impact with respect to applications, cost (capital, production, environmental) and probable reliability.

Student Outcomes covered by the Course:

ABET A: Ability to apply mathematics, science and engineering principles;
ABET B: Ability to design and conduct experiments, analyze and interpret data.
ABET C: Ability to design a system, component, or process to meet desired needs.
ABET D: Ability to function on multidisciplinary teams.
ABET E: Ability to identify, formulate and solve engineering problems.

ABET G: Ability to communicate effectively;
ABET H: The broad education necessary to understand the impact of engineering solutions in a global and societal context;
ABET J: Knowledge of contemporary issues

Topics Covered:

I. Introduction: How can you determine what steps or processes are critical in manufacturing? How are processing and manufacturing related? What are the most common processing routes? What is meant by flexible manufacturing? What processes or products require clean room techniques?

II. Ceramic products where mechanical properties are limiting
All ceramic airplane windows: Final mechanical properties are the critical limiting factor - the product and manufacturing process must be tailored to fit "existing" specifications.
•Fractrography- post failure analysis of failed parts to learn why and how they failed - includes laboratory exercise
•Biaxial flexure-choosing the "correct" mechanical properties test and analyzing the results (includes Weibull Statistics) - may include laboratory exercise
• Structure, processing and forming of non-crystalline ceramics- why do glasses behave the way they do mechanically? In general, how would we make an airplane window?
• Structural ceramics-what properties are important? what "model" properties may be useful? - likely to include a guest lecture on materials selection and trade-offs for a real application

III. Ceramic Products where electrical properties are limiting
A. Discrete Electronic Ceramics
Varistors: Electrical properties are the critical factor - how can the manufacturing process produce reliable varistors with the required microstructure and electrical behavior (non-liner IV characteristics with the appropriate turn on voltage, turn on rate, etc.)
• Laboratory exercise illustrates conventional powder processing and the effects of firing atmosphere on microstructure and electrical properties and electrical characterization
• Plant tour of Trans Tech (ceramics for microwave communications and advanced polycrystalline ceramics)
B. Cost Performance Modeling (Technical Cost Models) for Electronic Ceramics
• Team project (on-going through most of the semester)
C. LTCC Ceramics (Low temperature co-fired ceramic packaging)
Example of a system rather than a discrete product where design, component compatibility, and several process steps are critical
• Plant tour of Northrop Grumman (side scan radar arrays via LTCC process in a clean room environment) if they will still admit outsiders
• Laboratory exercise illustrates LTCC circuit design and manufacturing procedures. (Extent of the exercise will depend on materials and time available).

IV. Student presentations