Syllabus for MSE 791-603- Mechanical Properties of Nanostructured Materials

Spring 2016: Time: 1:30-2:45  TuTh
Building: EB3  Room: 2220
Instructors:
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   Y. T. Zhu, Office: RBII, Room 308
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Course Prerequisites: MSE 500

Learning Outcomes: At the end of the course, students should:
1. be familiar with the important methods for processing nanostructured materials, especially those that are suitable for mechanical property studies.
2. be familiar with the concepts and theories for grain growth, with emphasis on grain growth of nanostructured materials and the strategies to inhibit grain growth
3. apply testing methods to evaluate mechanical properties in nanostructured materials.
4. modify microstructure to optimize mechanical properties in nanostructured materials.
5. identify failure modes in creep, fracture and fatigue in nanostructured materials.
6. learn fundamental deformation mechanisms of nanostructured materials that are responsible for their mechanical behavior
7. be able to use the knowledge of deformation mechanisms to design nanostructured materials and their microstructures for superior mechanical properties

Text requirements: no required text, references will be given and selected references will be on reserve in the Hunt Library.

Course Overview: This course will describe the mechanical behavior that is unique to nanostructured materials – typically metallic materials. The various methods for processing nanostructured materials will be presented, emphasizing those that are suitable for mechanical property studies. The thermal stability of nanocrystalline microstructures will be covered and strategies for inhibiting grain growth described. Mechanical testing for uniaxial loading, creep, fracture and fatigue will be covered. The testing modes will be discussed in terms of structure-property relations, deformation mechanisms and failure modes. The influence of nanoscale microstructures on mechanical properties and failure modes will be emphasized. The deformation mechanisms of nanostructured materials will be presented and compared with those for conventional course-grained metals.
Deformation mechanisms that are responsible for the unique mechanical properties of nanostructured materials will be discussed. Principles and examples for designing nanostructures to activate certain deformation mechanisms for superior mechanical properties will be presented.

Tentative Lecture Schedule – Spring 2016

**Module 1: Professor Carl C. Koch (Material Science and Engineering)**

January 7  Introduction, overview of the field of nanoscience, nanotechnology
January 12  Methods to synthesize nanostructured materials (inert gas condensation, physical vapor deposition, chemical reactions)
January 14  Methods continued (electrodeposition, rapid solidification, solid state deformation)
January 19  Methods continued (mechanical alloying, powder consolidation)
January 21  Experimental methods for measuring thermal stability and grain growth
January 26  Grain growth, conventional grain size materials, nanostructured materials
January 28  Strategies for inhibiting grain growth in nanostructured materials
February 2  Review for Test 1, Homework #1 due.
February 4  **Test 1.**

**Module 2: Professor Ronald O. Scattergood (Material Science and Engineering)**

February 9  Introduction, stress – strain curves, mechanical testing, ductility.
February 11  Plastic deformation, dislocations, twinning and transformation.
February 16  HP relation, dislocation sources, strengthening mechanisms, models.
February 18  Mechanism transitions, size scale and temperature effects.
February 25  Particle strengthening, thermal activation, rate effects and creep.
March 1    Fracture, fatigue and surface effects.
March 3    Review for Test 2, Homework #2 due.
March 8    Spring break
March 10   Spring break
March 15   **Test 2**

Module 3: Professor Yuntian Zhu (Material Science and Engineering), tentative schedule

March 22   Introduction, fcc, bcc and hcp crystal structures, partial and full dislocations in fcc metals,
March 24   Twin morphologies: growth twins and deformation twins
March 29   Difference in the deformation of coarse-grains and nano-grains
March 31   Macroscopic strains at grain level produced by deformation twins
April 5    Grain size effect on deformation twinning and detwining in nc fcc metals. Optimal grain size
April 7    Deformation mechanisms of nanocrystalline bcc metals
April 12    utilizing deformation mechanisms to design nanostructured materials for superior mechanical properties
April 14    Review for Test 3
April 21    Test #3

Course Grading: Each module will account for 1/3 of the final grade.
Homework: 9%
Test #1:    30%
Test #2:    30%
Test #3:    30%

Grading Scale:
Grading will follow the guidelines given below:

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<th>Grade</th>
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<tr>
<td>A+</td>
<td>96 and above</td>
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<td>A</td>
<td>92-95.9</td>
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<td>A-</td>
<td>88-91.9</td>
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<td>84-87.9</td>
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<td>C+</td>
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Policies and Procedures for Distance Students (this is also OK for me (YTZ))
1.   On-line office hours. Koch, Scattergood, and Zhu are typically available most times during the work day. Email is best for asking questions.
2.   All online/distance education students must work with the Engineering Online staff to secure a proctor. Visit the Engineering Online web site at http://EngineeringOnline.ncsu.edu for more information about the selection of a proctor.
3.   Please turn in homework directly to the professors. Use Word or PDF files.

Policy on Late Assignments and Incomplete Grades
Assignments are due on or before the time and date indicated on the assignments. Due dates can be extended for students with valid reasons as defined by the NCSU Attendance policy at: www.ncsu.edu/policies/academic_affairs/courses_undergrad/REG02.20.3.php.

In cases where the conflict can be anticipated, prior arrangements must be made with the instructor to receive an extension. In cases of illness or family emergency, the student may be required to present documentation or other proof to receive an extension.

Homework assignments, if not handed in to the instructor by the due date, will lose 20% of their possible points for each day the assignment is late. This includes Saturdays and Sundays.

The university policy regarding incomplete grades (IN) applies to this course. See
http://ncsu.edu/policies/academic_affairs/grades_undergrad/REG02.50.3.php for instructor’s policy on IN
grades.

Academic Integrity Statement
It is expected that each student will complete his/her own homework, quizzes, and exams with academic integrity. Students shall follow the NCSU Code of Student Conduct (http://www.ncsu.edu/policies/student_services/student_discipline/POL11.35.1.php)

In addition, your signature on any test or assignment means that you neither gave nor received unauthorized aid. In other words, your signature on to-be-graded work in this course communicates an understanding of, and adherence to, the University Honor Pledge: “I have neither given nor received unauthorized aid on this test or assignment.”

Students with Disability Policy
Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with Disability Services for Students at 1900 Student Health Center, Campus Box 7509, 515-7653. http://www.ncsu.edu/dso/

Students with disabilities should contact the instructor for any additional assistance. Federal law mandates that the faculty provide reasonable accommodations to students with disabilities. (See NC State’s Academic Regulation for providing accommodations for students with disabilities.)