# Course Approval Form

**Coll./Schl./Div.:** College of Engineering  
**Dept./Comm./Prog.:** Electrical Engineering  
**Action:** CHANGE  
**Course Level:** Graduate Course  
**Course Type:** Standard Course  
**Effective:** Winter 2018  
**Offered once only:** No  
**Offered summer sessions only:** No  
**Quarter(s) Offered:** Fall, Winter, Spring  
(Previously Fall, Winter, Spring)  

**Last Approved Form Effective:** Spring 2016 (Submitted: 06/01/2015)  
**Notes:** Previously Approved  

<table>
<thead>
<tr>
<th>Previously Approved</th>
<th>Proposed</th>
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<tbody>
<tr>
<td><strong>Course Number:</strong></td>
<td>EE 206</td>
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<tr>
<td><strong>Course Title:</strong></td>
<td>Nanoscale Characterization Techniques</td>
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<tr>
<td><strong>E-Z Segment Title:</strong></td>
<td>Nanoscale Characterization Techniques</td>
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<tr>
<td><strong>Units:</strong></td>
<td>4</td>
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</table>
| **Activity(ies):** | Lecture, 3 hours per week (group activity)  
Laboratory, 3 hours per week (group activity) |
| **Prerequisite(s):** | EE 201/MSE 207 or consent of instructor |
| **Description:** | An in-depth study of nanoscale materials and device characterization techniques.  
Emphasizes atomic force microscopy (AFM) and scanning tunneling microscopy (STM).  
Includes semiconductor fabrication fundamentals; |
|                     | EE 201/MSE 207 or consent of instructor |
|                     | An in-depth study of nanoscale materials and device characterization techniques.  
Emphasizes atomic force microscopy (AFM) and scanning tunneling microscopy (STM).  
Includes semiconductor fabrication fundamentals; |
metrology requirements; in situ monitoring; interconnects and failure analysis; principles of AFM, STM, and scanning electron microscopy; X-ray methods; optical and infrared techniques; and electrical characterization.

Grading
Type: Letter Grade only
In Progress: No
Statement:
Repeatable: No
Maximum Units:
Statement:
Cross-listed With: MSE 227

Justification:
MSE 227A
Justification: EE 206 and MSE 227 are already cross-listed, this is a renumbering of MSE 227 to 227A.

Credit Statement:

If repeatable, may be taken more than once per quarter: No (previously No)

Breadth Statement:

Instructor(s): Professor Jianlin Liu

Justification:
MSE graduate students are required to take at least one course each in 5 areas of study denoted by the MSE 201-209; MSE 210-219. MSE 220-229 course ranges. In these course ranges, native MSE courses are denoted by end numbers 0-3. MSE as a program (and not a department) also incorporates a large number of external, cross-listed courses. The cross-listed numbers reflect the department origination, e.g., an end number of 4 stands for a course cross listed from physics, an end number of 5 for chemistry. The end number 7 denotes a course cross-listed from electrical engineering. To accommodate a new course from Electrical Engineering (EE 208) into the MSE curriculum in the area of Materials Characterization or Simulation, the current course MSE 227/EE206 requires to be cross-listed as MSE 227A/EE206 to make room for MSE 227B/EE208. Notably, these can stand as core subject matter course of graduate studies in MSE; they are not special topics courses. Consequently, they need to be numbered in the A-D range and not in the E-Z range. Similar examples are abundant in the MSE catalog (e.g., MSE 225A/CHEM216A, MSE 225B/CHEM221B, MSE 225C/CHEM206A ).

Correspondence:
Overlaps/Duplicates Other Courses: This course is cross-listed with EE 206.

Affects Programs: No

Affects Prerequisites/Descriptions: No

Syllabus:

Department of Electrical and Computer Engineering
University of California at Riverside

EE206/MSE227A: Nanoscale Characterization Techniques

LEC Day: TR Time: 4:10pm-5:30pm; Location: OLMH 1133

LAB Time: 7:10pm-10:00pm; Day: T; Location: Pierce Hall 1441 (Scanning Tunneling Microscopy/Atomic Force Microscopy training and experiments)

Discussion (Office hours): M 4-5pm or by appointments

Instructor: Professor Jianlin Liu
Office: Rm. 439, Winston Chung Hall
Email: jianlin@ece.ucr.edu
Tel: (951) 827-7131

TA: Renjing Zheng
Email: rzhen002@ucr.edu
Tel: (951) 8276275

Credit: 4 units

Grading: Homework:10%; Midterm:30%; Final:30%; Final abstract and presentation:30%

Homework: 2 problem sets
One before midterm, and one before final exam will be distributed to students to work. In each set, several problems are designed to help students to understand the content taught in the respective period. In the first set, the problems are associated with content in Optical Microscopy and Electron Microscopy, and in the second set, the problems are associated with content in Scanning Probe Microscopy. Each problem set has 5% of credit to claim, therefore total credit for homework is 10% of total credit.

Midterm: May 12
Final: To be determined
Presentation: Week 10; 7-minute presentation
(Show up on time in exams, no make-up exam)

Prerequisite: EE201/MSE 207 or consent of instructor

Scope:
Primary educational objective of this course is to familiarize the student with the principles of nanostructure characterization methods and provide hands-on experience in some of these methods. Lecture part will cover structural characterization techniques including optical microscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), atomic force...
microscopy (AFM), scanning tunneling microscopy (STM), near-field scanning optical microscopy (NSOM), and other techniques. Nanoscale characterization laboratory will allow students to operate nanoscale materials and devices characterization tools such as SEM, TEM, AFM and STM etc.

Textbook:
Handouts
Note: The handouts are the only reading materials provided in this course and the topics are listed in the table on next page. Some of the materials to be covered in the class lectures are not available in any reference books listed below, please show up in class, take notes and ask questions if any.

Course website: ilearn
(The handouts are pdf files and will be posted on ilearn in due course)

References:


Course lecture plan and reading lists *

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Week Contents

1 Introduction of EE206/MSE227A
   Review: nanostructures and nanodevices

2 Optical microscopy

3 Scanning electron microscopy (SEM)-I

4 Scanning electron microscopy (SEM)-II
   Transmission electron microscopy (TEM)-I

5 Transmission electron microscopy (TEM)-II

5 Midterm
6 Scanning tunneling microscopy (STM)-I
7 Scanning tunneling microscopy (STM)-II
8 Scanning tunneling microscopy (STM)-III
Atomic force microscopy (AFM)
9 Atomic force microscopy (AFM)
Near-field scanning optical microscopy (NSOM)
10 Other nanostructure characterization techniques
10 Final presentation
11 Final exam

* May vary according to actual progress

Tentative laboratory schedule:

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<table>
<thead>
<tr>
<th>Week</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lab safety training (online training: <a href="http://ehs.ucr.edu/training/online/">http://ehs.ucr.edu/training/online/</a>, take the &quot;Laboratory Safety Orientation&quot; course)</td>
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<tr>
<td>2-3</td>
<td>Training: Group I: AFM (CNSE clean room); Group II: STM (Pierce Hall 1441) Group I: STM (Pierce Hall 1441); Group II: AFM (CNSE clean room)</td>
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<tr>
<td>4-9</td>
<td>AFM Lab (Your own samples (preferred) or quantum dot samples provided); STM Lab (Graphite)</td>
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<tr>
<td>10</td>
<td>Laboratory report due, presentation slides due and presentation</td>
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This course is a laboratory-oriented course. Each student will do AFM laboratory, or STM laboratory or other laboratories with consent from instructor. Labs are carried out together, however, each student shall be able to operate the instrument, obtain data, prepare his/her own 2-page lab report and presentation, and present own results. It is encouraged that you characterize as many samples as you can assuming the lab time is allowed. The single-spaced 2-page lab report shall resemble an extended abstract for a "conference" which may include procedure of operation of the instrument, sample descriptions, characterization results, and concise analysis of the results. The presentation (7-minute talk) shall resemble a research conference presentation. Laboratory report and presentation slides are due before the presentation in week 10.

Approvals:
Department/Committee/Program Faculty:
Submitted by
Department/Committee/Program Chair:
Reviewed by Courses Specialist:
Reviewed by Dean of
College/School/Division:

Executive Committee
College of Engineering:
College of Humanities, Arts, and Social Sciences:
College of Natural and Agricultural Sciences:
Division of Biomedical Sciences:
Graduate School of Education:
Graduate School of Management:
University Honors Program:

Dean of the Graduate Division:
Graduate Council:

Committee on Courses:

<table>
<thead>
<tr>
<th>Home page</th>
<th>Client/Server</th>
<th>UC Riverside</th>
<th>Help</th>
</tr>
</thead>
</table>

https://cramsportal.ucr.edu/crams/printForm.print_course?p_sCourse_id=1000005797&p_...  5/30/2017