

USC Viterbi

School of Engineering

MASC 512: Thin Film Science and Technology (4 units)
Fall 2020

Lectures: Mon, Wed 10:00 to 11:50 AM (online *via* Zoom).

Instructor: Dr. Jayakanth Ravichandran

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Office hours: After class or by appointment.

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Course Description: *The course introduces the science and technology of thin films to graduate students.* The course will cover the historical developments and motivation to achieve thin films, common synthesis techniques, materials characterization, physical properties, and applications of thin films. The students are typically with graduate standing in any of the relevant physical science or engineering disciplines including but not limited to Materials Science, Electrical Engineering, Mechanical Engineering, Chemical Engineering, Physics or Chemistry.

Learning Objectives: The course is aimed at teaching the basics of thin film science and technology, which is one of the important forms of materials preparation. The course will cover the necessary basics from thermodynamics, electrodynamics, quantum mechanics, and solid state physics relevant to thin film science. The course will emphasize on the techniques, properties of materials in thin film form, and the technologies developed from these materials. At the end of this class, the student is expected to have a broad understanding of the status of thin film technology.

Recommended Preparation: Upper division or graduate level preparation in thermodynamics and quantum mechanics or solid-state physics. Students can request waiver for these prerequisites, if they have the necessary background.

Books: Lecture slides will be provided and will contain all the information and necessary references to learn the material. In some cases, lecture notes will be supplemented. Significant material will be covered from these two textbooks.

1. Smith, Donald Leonard. *Thin-film deposition: principles and practice*. Vol. 108. New York etc: McGraw-hill, 1995. ISBN: 978-0070585027

2. Ohring, Milton. *Materials science of thin films*. Academic press, 2001. ISBN: 978-0125249751

Grading:

Problem Sets (3)	(3 x 10)	=	30%
Term Paper/Critical Review (Mid-term = 15%; Final = 25%)		=	40%
Lecture notes (10% x 3 or 15% x 2)		=	30%

Problem sets policy:

There will be three problem sets posted roughly at one every 4-5 weeks' interval. The homework will be due in about 10 days' time after the posting. Each homework will count for 10 points. The homework will consist of problems, which are descriptive in nature, thought-type questions, numerical problems and/or simple mathematical simulations solved using a computer program.

Lecture notes:

The students will be assigned 2-3 lecture note(s) preparation depending on the size of the class. The notes could include multiple lectures. The notes are descriptive write up 5-15 pages of the material covered in each lecture. The notes schedule will be posted before the first week of the class but could change as the enrollment of the students fluctuate over the semester.

Term Paper/Critical Review Policy:

The term paper will be used as a method to evaluate the student's performance and one of them will act as the final summative performance and the other for mid-term performance. The students are expected to write a brief review of a selected topic in this term paper. For example, topics relevant to thin film growth, and/or properties of novel thin films. You are also expected to typeset this article in a scientific journal format (*e.g.* Nature, Science, Advanced Materials, Physical Review Letters *etc.*) and mention the journal name in the review. Use any suitable schematics derived from any source (with suitable citations). There will be a class presentation that you are expected to prepare based on the report. The grade will be split between the report and the presentation.

Presentation:

The presentation will be a 10-minute presentation with 2-minutes for Q&A. The rubric for the presentation is given below. The grading for the presentation will be performed by your fellow students attending the presentation. The presentation will be a good opportunity to get feedback to prepare a compelling critical review.

Mid-term: (Credit for report: 10%; Presentation: 5%)

You are expected to write this article in under 5 pages. This is a critical review of an article published in the **last 5 years**.

Final term paper: (Credit for report: 15%; Presentation: 10%)

This final term paper will be due during the finals week. This will be a brief review of a topic related to the class. It will be drafted in a perspective format (<https://www.nature.com/nature/for-authors/other-subs>). Please follow the length and other guidelines provided in the link.

The breakdown for the evaluation for the term paper is as follows:

Selection of topic, and its relevance to the course	– 10%
Formatting per the journal guidelines	– 20%
Content of the review	– 50%
Figures and Caption	– 10%
References	– 10%

The breakdown for the evaluation for the presentation is as follows:

Formatting	– 20%
Content	– 50%
Delivery	– 30%

Topics covered and weekly breakdown of course schedule:

- 1) Introduction:
Why thin films? – Physics and Engineering Perspective, Materials Science basics.
- 2) Vacuum Technology:
Kinetic theory of gases, Vacuum systems, creation and measurement of vacuum.
- 3) Film growth and Phenomenology:
Symmetry, surfaces and interfaces, Thermodynamics and Kinetics of thin film deposition and growth.
- 4) Thin film Deposition Methods:
Physical and Chemical deposition methods, Plasma based deposition methods.
- 5) Characterization of films:
Structural and chemical characterization of thin films – Methods and mechanisms.
- 6) Thin film properties:
Thermodynamic and transport properties of thin films (Mechanical, Electrical, Thermal, Magnetic, Optical *etc.*)
- 7) Applications of Thin films:
Electronic, optical, mechanical, thermal, and energy applications of thin film technology.
- 8) Emergent research activities in thin film science and technology

	Topics/Daily Activities	Readings and Homework	Deliverable/ Due Dates
Week 1	1.1 Introduction & Review of Materials Science	Notes, Ohring Ch1	
Week 2	1.2 Review of Materials Science 2.0 Historical Perspectives 2.1 Vacuum Technology	Notes, Ohring Ch1,2	
Week 3	2.2 Vacuum Technology	Notes, Ohring Ch2	Mid-term critical review topic/article choice due
Week 4	3.1 Thin Film Deposition – Vacuum Based Methods	Notes, Ohring Ch3,4	
Week 5	3.2 Thin Film Deposition – Vacuum Based Methods	Notes, Ohring Ch4,5, 6	Problem Set 1 is posted
Week 6	3.3 Thin Film Deposition – Vacuum Based Methods	Notes, Ohring Ch5,6	Problem Set 1 is due
Week 7	3.4 Thin Film Deposition – Low Vacuum and Ambient Methods	Notes	Mid-term critical review presentation
Week 8	4.1 Film Growth and Phenomenology	Notes, Ohring Ch7,8	Mid-term critical review due
Week 9	4.2 Film Growth and Phenomenology	Notes, Ohring Ch7,8	
Week 10	5.1 Characterization of Films – Inorganic Hard Materials	Notes, Ohring Ch10	Problem Set 2 is posted
Week 11	5.2 Characterization of Films – Inorganic Hard and Organic Soft Materials	Notes, Ohring Ch10	Problem Set 2 is due
Week 12	6.1 Properties of Thin films – Structural, Electrical, Optical, Thermal	Notes, Ohring Ch12	Final term paper topic selection due
Week 13	6.2 Properties of Thin films – Structural, Electrical, Optical, Thermal, Biological	Notes	Problem Set 3 is posted
Week 14	7. Applications of Thin Films – Hard and Soft Materials	Notes	Problem Set 3 is due
Week 15	8. Emergent Activities – Hard and Soft Materials	Notes	Final term paper presentation
FINAL			No Final Exam/ Final Paper to be submitted in Finals Week

Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, “Behavior Violating University Standards” policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, policy.usc.edu/scientific-misconduct.

Support Systems:

Student Health Counseling Services - (213) 740-7711 – 24/7 on call

engemannshc.usc.edu/counseling

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call

suicidepreventionlifeline.org

Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-4900 – 24/7 on call

engemannshc.usc.edu/rsvp

Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) | Title IX - (213) 740-5086

equity.usc.edu, titleix.usc.edu

Information about how to get help or help a survivor of harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following protected characteristics: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations.

Bias Assessment Response and Support - (213) 740-2421

studentaffairs.usc.edu/bias-assessment-response-support

Avenue to report incidents of bias, hate crimes, and microaggressions for appropriate investigation and response.

The Office of Disability Services and Programs - (213) 740-0776

dsp.usc.edu

Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Support and Advocacy - (213) 821-4710

studentaffairs.usc.edu/ssa

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101

diversity.usc.edu

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call

dps.usc.edu, emergency.usc.edu

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call
dps.usc.edu

Non-emergency assistance or information.