

USC Viterbi

School of Engineering

MASC 512: Thin Film Science and Technology (4 units)
Fall 2024

Lectures: Mon, Wed 10:00 to 11:50 AM (VHE 206).

Instructor: Dr. Jayakanth Ravichandran

Office: VHE 714

Office hours: After class or by appointment.

Email: jayakanr@usc.edu.

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	(Presentation = 15%; Report = 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 Policy:

The term paper will be used as a method to evaluate the student's performance and 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.

Final term paper: (Credit for report: 25%; Presentation: 15%)

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	
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	
Week 8	4.1 Film Growth and Phenomenology	Notes, Ohring Ch7,8	Final term paper topic selection 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	
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 University Academic and Support Systems

Students and Disability Accommodations:

USC welcomes students with disabilities into all of the University's educational programs. [The Office of Student Accessibility Services \(OSAS\)](#) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Student Financial Aid and Satisfactory Academic Progress:

To be eligible for certain kinds of financial aid, students are required to maintain Satisfactory Academic Progress (SAP) toward their degree objectives. Visit the [Financial Aid Office webpage](#) for [undergraduate](#)- and [graduate-level](#) SAP eligibility requirements and the appeals process.

Support Systems:

[Counseling and Mental Health](#) - (213) 740-9355 – 24/7 on call

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

[988 Suicide and Crisis Lifeline](#) - 988 for both calls and text messages – 24/7 on call

The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline

consists of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

[Relationship and Sexual Violence Prevention Services \(RSVP\)](#) - (213) 740-9355(WELL) – 24/7 on call

Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

[Office for Equity, Equal Opportunity, and Title IX \(EEO-TIX\)](#) - (213) 740-5086

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

[Reporting Incidents of Bias or Harassment](#) - (213) 740-2500

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

[The Office of Student Accessibility Services \(OSAS\)](#) - (213) 740-0776

OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

[USC Campus Support and Intervention](#) - (213) 740-0411

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

[Diversity, Equity and Inclusion](#) - (213) 740-2101

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

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) 442-1200 – 24/7 on call
Non-emergency assistance or information.

[Office of the Ombuds](#) - (213) 821-9556 (UPC) / (323-442-0382 (HSC)

A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

[Occupational Therapy Faculty Practice](#) - (323) 442-2850 or otfp@med.usc.edu

Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.

