

Fundamentals of Soft Nanomaterials and Nanostructures

School of Materials Science and Engineering

MSE 4335/8803B Spring 2023
College of Computing, room 102
Tuesday, Thursday, 12.30-1.45 pm

Prerequisites: MSE 2001 or instructor consent

Course Overview

The purpose of this course is to discuss fundamentals and the types of soft (polymer, organic, and biological) nanomaterials and corresponding hybrid nanostructures that have been discovered and synthesized for prospective applications in nanotechnology such as flexible nanostructures, soft nanoparticles, hybrid nanomaterials, soft lithography, colloidal assemblies, self-assembled organic structures, and biological complexes.

Course Description

The multi-disciplinary aspect of nanotechnology crosses the traditional disciplines of physics, chemistry, biology and materials engineering. Fundamental principles, physical phenomena, synthesis protocols and physical/chemical properties of soft nanomaterials will be discussed with particular emphasis on organic, polymeric, biological, and hybrid (organic-inorganic) assemblies at a length scale ranging from 1 nm to 1000 nm. The course will be composed of three closely related modules with emphasis on: soft matter fundamentals (I) (20%), organization and properties of soft nanomaterials (II) (20%), and advances and applications of soft nanomaterials (III) (60%). Team research video presentations will explore very recent applications relevant to student research interests.

Instructor: Prof. Vladimir V. Tsukruk. MSE; 3100M, Molecular Science @ Engineering Bldg; ph.: 8946081, vladimir@mse.gatech.edu

Class composition and duties

Teaching methods: Lectures, team discussions, mid-term exams, executive research summaries (for graduate students):

- course will be taught in a live mode
- mid-term exams and homework assignments
- research projects (research videos) will be done in small groups
- student team YouTube video research presentations
- student participation and arbitrating

Module I
Soft Matter Fundamentals (time 20%)
Exam 1

Module II
Organization and Assembly of Soft Nanomaterials (time 15%)
Exam 2

Module III
Properties and Application of Soft Nanomaterials (time 65%)
Exam 3

Final exam: Research team video presentations

Exams: There will be three mid-term exams each of them closely related to a particular module. The final exam is a research video presentation ranked by class and instructors.

Final research team video presentations: Students will form research teams (4-5 students in a team), prepare a research video for YouTube and will deliver a video presentation in class. This assignment is the final exam grade. The topics will be selected and discussed in class and video ranking will be conducted by classmates along with instructor and TAs. Scripts and video trails will be graded separately.

Graduate students in addition to video presentation provide executive summary of critical review (2 pages) on research topic, which is graded separately. Topic for critical review summary is the same as that for research video. Focus is on the state of the art in the field and critical issues to focus on. 2 pages of text: 1 spacing, 11 font; 1-2 figs, <15 references.

Grade contributions, 45%

Midterm exam 1	15%
Midterm exam 2	15%
Midterm exam 3	15%

Homeworks, 20%

Scripts, all teams	10%
(Research abstract, graduate students only)	10%, averaged with script score
Video trails, all teams	10%

Final exam, 35%:

Video Research Presentation	35%, include individual contributions
Research video contribution/participation	± 3%
Total	100%

Grading scale:

A: 86-100%; B: 76-85%; C: 66-75%; D: <65%

References: A list of reference books/links will be provided in the beginning of class. Also references to recent science and technology reviews, web-links, and papers will be provided/cited in classes.

Module I

Soft Matter Fundamentals

Date	Lecture #	Activities
January 10	1-2	Introduction-video 1/1, 1/2 (Sml), student videos examples
12	1-2	Chemical composition/structures, polymers/biopolymers
17	3	Configuration, conformation, local/global flexibilities
19	4	Entropy, enthalpy, dynamics, and solutions
24	5	Thermal and mechanical properties. 2/5 (Smr, 25.36-33.53); Review, Part 1
26		Midterm exam 1, Maddy

Module II

Organization and Assembly of Soft Nanomaterials

31	6	Surface and interfacial organization-video 2/3 (Smr, 2.30-11.38)
February 2	7	Colloidal assemblies, Nanoparticles, video 1/5 (Sml, 35.13-46.12) Team/topic selection due, Maddy
7	8	Molecular films and Polymer Brushes
9	9	Layer-by-layer assemblies, Concepts review, Part 2
14		Midterm exam 2, Maddy

Module III

Properties, Applications, and Trends in Soft Nanomaterials

16	10	Responsive nanomaterials, self-healing-video 2/5 (Smr, 34.20-41.13)) HW1: Scripts due
21	11	Hybrid nanoparticles Scripts discussion, Maddy
23	12	Soft membranes- video 2/6 (Cln?)
28	13	Soft nanocomposites, video S3
March 2	14	Soft Lithography, video trails/rubrics discussion, Maddy
7	15	Controlled drug delivery, video 1/6 (Sml) + S2, S5
9	16	Biomimetic engineering-video 2/3 11.38-18.56), 2/7 (Smr); 1/6 (Str)
14	17	Flexible electronics, video 1/4 (Sml, 10.03-23.06) + S7
16	18	Wearable electronics, Videos S5, S8
21		Spring break
23		Spring break
28	19	Organic photonics/electronics 1 - video 2/8 (Smr)
30	20	Organic photonics/electronics 2, HW2: Video Trails + GRA abstract due, Maddy
April 4	21	3D/4D printing technologies+video S1
6	22	Computational design of soft nanomaterials
11	23	Soft robotics
13		Midterm exam 3, Maddy
18	24	General trends in soft nanomaterials research
20	Final Exam	Research Video Presentations, Teams 1-4, Maddy, YouTube upload, 10am
25	Final Exam	Research Video Presentations, Teams 5-7, Maddy
27	25 Reading Period	Class experience, suggestions, Q&A
May 1	Reading Period	May 1, -No exam, use as a reading window

Red font indicates special assignments, due dates, exams, presentations