Course Syllabus

VK493 Self-assembly of Materials and Devices

Fall 2023

Course Description:

Self-assembly is the process by which matters from molecules to living organisms to stars form ordered spatiotemporal structures. It has produced not only novel materials but also innovative solutions in device fabrication in electronics and photonics. This course will introduce fundamental forces at small scales that are essential to the understanding of microscopic self-assembly. The course is divided into two parts: equilibrium self-assembly and non-equilibrium self-assembly. The former includes polymers, colloidal particles and porous materials. The latter includes the more futuristic materials or material systems such as active matter, nanomachines, and microrobots. Part of the course materials will be drawn from the primary literature.

Instructor:

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Office hour: by appointment

Reference Book (Author, Book Title, Publisher, Publication Year, ISBN):

Israelachvili, J. N. *Intermolecular and surface forces*. (Academic Press, 2011). ISBN: 978-0-12-375182-9

Ozin, G. A., Arsenault, A. C. & Cademartiri, L. *Nanochemistry: a chemical approach to nanomaterials*. (Royal Society of Chemistry, 2009). ISBN: 978-3-527-33120-8

Wang, J. *Nanomachines: fundamentals and applications*. (Wiley-VCH, 2013). ISBN: 978-3-527-33120-8

Lecture:

Students are expected to attend every lecture.

Time:

10:00 – 11:40 on Tuesdays and Thursdays (or 16:00 - 17:40 on Mondays and Wednesdays), to be decided.

Course prerequisites:

VP240/VP245/VP250/VP260, VC209/210, or equivalent 2nd year chemistry and physics courses

Classroom:

TBA

Grading Policy (Assignments %, Exams, etc.)**:**

Homework (30%)
In-class tests (20%)
Literature paper presentation (20%, group project)
Proposal presentation (10%, individual project)
Final exam (20%)

Honor Code Policy:

We follow the guidelines set out by the JI honor code:

https://www.ji.sjtu.edu.cn/academics/academic-integrity/honor-code/

Some more specific requirements:

You are encouraged to discuss with your classmates about the problems in the homework and the proposals, but you must complete these assignments on your own. Presentations will be judged by both contents and clarity of delivery.

Tentative schedule:

Week	No.	Date	Lectures	Notes
1	1	12 Sept.	Introduction to self-assembly and an overview of the course. Thoughts on learning and teaching creativity.	
	2	14 Sept.	Review (re-introduction) of basic concepts in thermodynamics: entropy, temperature, and Boltzmann distribution	
2	3	19 Sept.	Forces between atoms and molecules: ionic, covalent, van der Waals forces, hydrogen bonding, steric repulsion	
	4	21 Sept.	Forces between atoms and molecules continued	
3	5	26 Sept.	Thermodynamics of equilibrium self-assembly, surfactant micelles	
	6	28 Sept.	Self-assembly of polymers and applications in electronics	
4		1 - 7 Oct.		Holiday
5	7	10 Oct.	Self-assembly of mesoporous materials and application in catalysis and biomedicine	
	8	12 Oct.	Self-assembly of DNA molecules, DNA origami, and applications in biotechnology	
6	9	17 Oct.	Forces between particles and surfaces I: electrostatic and long-range vdW forces, DLVO theory	
	10	19 Oct.	Forces between particles and surfaces II: solvation, structural, hydration forces, steric and thermal fluctuation forces	
7	11	24 Oct.	Forces between particles and surfaces III: adhesion and wetting phenomena, friction and lubrication	
	12	26 Oct.	Self-assembly of colloidal spheres and application in photonics	
8	13	31 Oct.	Self-assembly of nanorods, nanotubes, nanowires,	

			and applications in electronics and biomedicine	
	14	2 Nov.	Review of the first part on equilibrium self-assembly and refresh on necessary aspects of statistical mechanics for the second part	
9	15	7 Nov.	Overview of the non-equilibrium self-assembly: self-organization, pattern formation, active mater, swarms, life, robots, and cybernetics	
	16	9 Nov.	Brownian motion, bacteria, microswimmers and life at low-Reynolds number	
10	17	14 Nov.	Brownian motion II, Langevin dynamics, stochasticity, and collective robots	
	18	16 Nov.	Bird flocks, Vicsek model, phase transition	
11	19	21 Nov.	Maxwell demon, stochastic heat engine, information engine	
	20	23 Nov.	Protocells and origin of life; student project presentation	
12	21	28 Nov.	Molecular motor and thermodynamically consistent random walk; student project presentation	
	22	30 Nov.	Synchronization	
13	23	5 Dec.	Information, order, and cybernetics; proposal presentation	
	24	7 Dec.	Proposal presentation, review and parting thoughts	
14				

Note: