Two-dimensional Materials and Applications (MAT 526), Spring 2024

Instructor: Asst. Prof. Ongun Özçelik
e-mail: **ongun.ozcelik@sabanciuniv.edu**
Office: FENS-1025
Office hours: Online or in office upon demand. Please send an e-mail to arrange a meeting.

Course information:
The course is research oriented and successful students will be able to contribute to research papers at the end of the course. Students will learn the remarkable phenomena occurring at lower dimensions which are universally applicable to a wide range of two-dimensional materials and their heterostructures. The course will provide the fundamental physics&chemistry knowledge required to understand the macroscopic behaviors of two-dimensional materials starting from graphene and spanning a wide range of spectrum including graphyne, boron nitride, transition metal dichalcogenides, silicene, germanene, phosphorene, antimonene, nitrogene, metal hydroxides and polymers in two-dimensional networks. Important applications of two-dimensional materials in energy storage/harvesting, carbon capture and water filtering devices as well as quantum effects such as superconductivity, superlubricity and nano-capacitance will be discussed.

List of discussion topics (tentative)

- Perspectives on nano science and two-dimensional (2D) materials: Early developments
- Complexity in the simplicity of 2D materials (structure, stacking, Moire patterns)
- Graphene: Electronic, vibrational, thermal properties & applications
- Growth and synthesis of 2D materials
- Vertical and in-plane heterostructures of graphene: Nanocapacitors and transistors
- Newly emerging carbon based monolayers: Biphenylene networks & graphynes
- Strain engineering of 2D materials: Transition metal dichalcogenides.
- Optical properties and optoelectronic devices from 2D materials
- Defects in 2D materials: Carbon capture and water filtering applications
- Prediction and synthesis of silicene, germanene and stanene monolayers
- Prediction and synthesis of phosphorene, antimonene and nitrogene monolayers
- Two dimensional polymer and metal organic hybrid structures
- Future prospects in 2D materials: superconductivity, superlubricity and supercapacitance

Grading:

Discussions	: 20%
HW	: 20%
Midterm Proposal	: 20%
Final Project	: 40%

Reference Books:

(1) 2D Materials: Properties and Devices. Avouris, P., Heinz, T., & Low, T. (2017), Cambridge U. Press.
(2) Introduction to the Physics of Silicene and other 2D Materials, Cahangirov, S., Sahin, H., Le Lay, G., & Rubio, A. (2017), Springer.
(3) Graphene: A New Paradigm in Condensed Matter and Device Physics, Wolf, E. L., (2013), Oxford U. Press.
(4) Introduction to Nanoscience, Gabor Hornyak, L., Dutta, J., Tibbals H., & Anil K. (2008), CRC Press.