MATSCI 384 | Materials Advances in Neurotechnology: Materials Meeting the Mind
Fall 2018 Tue/Thu 12-1:20 (McCullough 122)

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Course Description

The dichotomy between the material world and the mental world has driven the curiosity of scientists to explore the wonders of the brain, as well as motivated the continued innovations of novel technologies based on advances in materials science and engineering to understand the brain. This course introduces the basic principles of materials design and fabrication for probing the inner workings of the brain, discusses the fundamental challenges of state-of-the-art neurotechnologies, and explores the latest breakthroughs in materials-assisted neuroengineering. The course will cover the following topics: understanding of the nervous system from an engineering perspective, mechanical and biochemical requirements of neural interfacing materials, materials for electrical/magnetic/optical/biochemical/thermal/acoustic neural interfaces and other materials as contrast agents for neuroimaging. Students will be able to speak the languages of both materials science and neuroengineering and acquire the knowledge and skills to understand and address pressing neuroscience challenges with materials advances.

Learning Objectives

By the end of this course, you will be able to

- Acquire the 'multilingualism' of physical sciences, neural science and engineering and demonstrate the skills to communicate effectively across the boundaries of different disciplines
- Synthesize a holistic view of modern neurotechnologies by associating the concepts of materials science with neuroscience in the context of historical development
- Develop the capability to critically evaluate the pros/cons of existing neurotechnologies from the materials science perspective
- Construct the knowledge and potential skillset to conceptually design new neurotechnologies based on the topics covered in this course

Grading

Homework (30%)
In-class discussion (10%)
Presentation (30%)
Course reflection (30%)

Your grade is determined according to your final score in percentage:

≥95% A+	≥80% B+	≥65% C+	≥50% D+	<40% NP
≥90% A	≥75% B	≥60% C	≥45% D	≥55% CR
≥85% A-	≥70% B-	≥55% C-	≥40% D-	<55% NC

Readings

Readings will be posted on the course website throughout the quarter:
https://canvas.stanford.edu/courses/90716

Note: After registering for MATSCI 384 on Axess you will have access to the full MATSCI 384 Canvas website, where you will find course materials, course announcements, course discussions and your scores on graded work.

Useful background materials (all titles in reserve at Green or Terman Engineering Library)
Very basic neuroscience:
Kandel, E. R., et al. *Principles of Neural Science*. McGraw-Hill Education (2012)
Glickstein, M. *Neuroscience: A historical introduction*. MIT Press (2014)

Elementary concepts from physics and chemistry:
Purcell, E. M., et al. *Electricity and Magnetism*. Cambridge University Press (2011)
Oxtoby, D. W., et al. *Principles of Modern Chemistry*. Brooks/Cole Cengage (2012)

Principles of materials science:
Steif, P. S. *Mechanics of materials.* Pearson (2012)
Ratner, B. D., et al. *Biomaterials Science: An Introduction to Materials in Medicine.* Elsevier (2013)
Streetman, B., et al. *Solid State Electronic Devices*. Prentice Hall (2006)
Plummer, J. D., et al. *Silicon VLSI Technology: Fundamentals, Practice, and Modeling*. Prentice Hall (2000)

Neurotechnology:
Carter, M., et al. *Guide to Research Techniques in Neuroscience*. Academic Press (2015)
Covey, E., et al. *Basic Electrophysiological Methods*. Oxford University Press (2015)

Course Schedule

September	25	Tu	course intro: advanced materials hold the key to unlocking the mystery of the mind
	27	Th	overview of neurotechnologies enabled by materials advances
October	2	Tu	understanding the brain at molecular/cellular level from an engineering perspective
	4	Th	understanding the brain at circuit/systems level from an engineering perspective
	9	Tu	basic principles of materials design and fabrication for neurotechnologies
	11	Th	materials for electrical neural interfaces (I) – ex vivo neural recording
	16	Tu	materials for electrical neural interfaces (II) – in vivo neural recording
	18	Th	materials for electrical neural interfaces (III) – stimulation electrodes
	23	Tu	materials for optical neural interfaces (I) – waveguiding materials for optogenetics
	25	Th	guest lecture (I) – Dr. Huiliang (Evan) Wang, Deisseroth lab
	30	Tu	materials for optical neural interfaces (II) – non-genetic optical modulation
November	1	Th	materials for optical neural interfaces (III) – optical readout of neural activity
	6	Tu	contrast materials for structural and functional brain imaging (I) – in vivo brain functional imaging

	8	Th	contrast materials for structural and functional brain imaging (II) – ex vivo brain structural imaging
	13	Tu	materials for biochemical neural interfaces
	15	Th	scaffold biomaterials for neural tissue engineering
	20	Tu	thanksgiving recess (no classes)
	22	Th	thanksgiving recess (no classes)
	27	Tu	guest lecture (II) – Prof. Raag Airan, Department of Radiology (tentative)
	29	Th	materials for other neural interfaces – magnetic and ultrasound stimulation
December	4	Tu	student presentation (I)
	6	Th	student presentation (II)

Attendance policy

Attendance will benefit you in several ways. Primarily, your understanding of the course material is heightened from attending the lectures (vs. reading the lecture notes – multisensory teaching/learning experience has been proved in cognitive neuroscience studies to improve learning). Second, discussions with your instructor, CA and fellow classmates in class help you assimilate the acquired knowledge more easily. If absences are necessary (which I understand, life happens), please attempt to contact me and I am happy to catch up with you on the missed course materials by scheduling one-on-one meetings.

Late assignment policy

If a student submits an assignment after the due date without having made arrangements with the mentor, 5% of the total points will be deducted every day the assignment is late after the assignment is due. No revision or redoing of the assignments is allowed after submission.

ADA policy

Students who may need an academic accommodation based on the impact of a disability must initiate the request with the Office of Accessible Education (OAE). Professional staff will evaluate the request with required documentation, recommend reasonable accommodations, and prepare an Accommodation Letter for faculty dated in the current quarter in which the request is being made. Students should contact the OAE as soon as possible since timely notice is needed to coordinate accommodations. The OAE is located at 563 Salvatierra Walk (phone: 723-1066, URL: http://studentaffairs.stanford.edu/oae).

Honor Code

The Stanford University Honor Code is a part of this course.

It is Stanford's statement on academic integrity first written by Stanford students in 1921. It articulates university expectations of students and faculty in establishing and maintaining the highest standards in academic work. It is agreed to by every student who enrolls and by every instructor who accepts appointment at Stanford. The Honor Code states:

1. The Honor Code is an undertaking of the students, individually and collectively
    1. that they will not give or receive aid in examinations; that they will not give or receive unpermitted aid in class work, in the preparation of reports, or in any other work that is to be used by the instructor as the basis of grading;

2. that they will do their share and take an active part in seeing to it that others as well as themselves uphold the spirit and letter of the Honor Code.

2. The faculty on its part manifests its confidence in the honor of its students by refraining from proctoring examinations and from taking unusual and unreasonable precautions to prevent the forms of dishonesty mentioned above. The faculty will also avoid, as far as practicable, academic procedures that create temptations to violate the Honor Code.

3. While the faculty alone has the right and obligation to set academic requirements, the students and faculty will work together to establish optimal conditions for honorable academic work.