

EECS 598: Organic Electronics: Fundamentals

Instructor: Steve Forrest

Term: Winter, 2017

Meeting time: MW 10:30 am – 12:00 pm

Today, there is a revolution in optoelectronics based on organic semiconductors: OLED displays are used in hundreds of millions of smart phones, televisions, tablets and smart watches worldwide. It is becoming increasingly clear, for example, that OLEDs have all but displaced liquid crystal displays in smart phones and tablets, and will soon dominate computer and television display markets. Organic solar cells are on the cusp of generating a new, ultralow cost renewable energy source. Yet the foundations for these emerging applications have been a subject of intense study for over 70 years, and in many cases are still not fully understood. In this course, we will trace the history, science and modern applications of organic electronic technology. The first of two semester course is dedicated to understanding the fundamentals of organic semiconductor materials. This includes consideration of crystal structure, bonding forces, and structure-property relationships of both small molecule and polymer semiconductors. The growth and technology of depositing high quality thin films and growing nearly perfect crystals will then be discussed. We provide a comprehensive description of the physics and materials properties leading to their unique optical and electrical properties. What are the characteristics that make organic semiconductors (sometimes known as “excitonic” materials) different from conventional semiconductors such as Si and GaAs? Exciton physics, charge transport, optical transitions, etc. are all developed to give a solid foundation in what distinguishes organic semiconductors from conventional electronic materials, and what characteristics make them suitable for applications that are now becoming increasingly ubiquitous.

The second half of the course (taught 1 year later) will concentrate on applications that exploit the unique characteristics of organics. We focus particularly on light emission in OLEDs, and how electron spin plays a significant role in organics, particularly in contrast to inorganic semiconductors. Then we address light detection in photodetectors and solar cells. Will the potentially low cost of these devices ultimately lead to their widespread use? Finally, we will examine advances in thin film transistors, lasers, and even molecular electronic devices, and their prospect for use in new, and even traditional optoelectronic applications.

This course is directed at students with a background in senior level quantum physics and electricity and magnetism. A comprehensive knowledge of chemistry is not required.