

To all ECE graduate students (and ECE faculty for information):

Re: **New course on nano-science and terahertz technology this fall semester**

**ECE 697MM, Special topic: From nano-science to terahertz technology.**

Instructor: Professor Sigfrid Yngvesson

This note is sent to all ECE graduate students to inform you that there will be a new special topics course this fall semester: *From nano-science to terahertz technology*. This course will complement our regular solid state curriculum (ECE 607, 609, 614, and 618) by introducing some specific material related to the very smallest structures (nanometer size) now used (or contemplated to be used) for electronic devices. All of you students are familiar with the fact that electronic devices are getting smaller and smaller. Part of the reason for this trend is to allow us to pack more devices on a single chip, and as a bonus the devices also operate faster. So we might think that by now transistors (digital and analog) must have reached terahertz frequencies? By terahertz frequencies I mean at least 1 THz ( $10^{12}$  Hz), although people often “cheat” and include less than that frequency as “terahertz”. No, we are not there yet! Can we get there by continuing to make present devices smaller and smaller? Why are terahertz frequencies important anyway? In order to discuss such questions, this class will take the approach: why not start with something really small, for which we know that we have to use quantum mechanics directly to describe the device. That is what has been going on the last few years in the field of nano-science, and at least some of this is motivated by the goal of inventing new electronic devices.

Some questions that we will address in this course are: What difference does the dimensionality of our device make? 3D, 2D (“2DEG”), 1D (quantum point contacts, quantum wires, carbon nanotubes, long molecules, etc.), or even 0D (quantum dots). Is it always necessary to make the device smaller to reach higher frequencies (think of a typical optical detector or a semiconductor laser!)? Many devices we will discuss are detectors, so how do we characterize their sensitivity? We will discuss several different types of noise processes relevant to terahertz detectors. What is “quantum noise” for example?

You might think that this course will require a very high level of background. Instead, I will start on a lower level, and also introduce extensive material about experiments and performance of a range of new devices. The main requirement is that you have some background in quantum mechanics, as acquired in ECE 607, for example. Of course, if you have also already had ECE 609 and/or 618 you will be more than adequately prepared (but these are *not* required).

I plan to start the course based on part of the material in the first three chapters from the classic book by Supriyo. Datta, “Electronic Transport in Mesoscopic Systems” (Cambridge University Press, 1995) which will serve as a text book. This book is

available in paper back. After this introduction, I will present all material in notes that will be made available on a web site. I will give you a more detailed syllabus just before the beginning of the fall semester. I plan to have the usual home work problems, two midterm exams, and a final project/term paper.