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A COURSE IN APPLIED SOLID STATE PHYSICS

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ABSTRACT

This paper describes a course on the applications of solid state physics which has been given twice in the Department of Physics of the University of California at Berkeley.

I. Introduction

Most physics departments offer a course in solid state physics, but few offer one on the applications of solid state physics. This paper describes a course in applied solid state physics that has twice been given in the Department of Physics of the University of California at Berkeley.

The course was a one-quarter series of about 30 lectures designed to be a sequel to the usual one- or two-quarter course in solid state physics taken by many physics students. The explicit prerequisite was such an introductory course in solid state physics at the level of Kittel's Introduction to Solid State Physics. This prerequisite placed the course at approximately the senior or first-year graduate level. The aims of the course were as follows. First, to broaden the range of knowledge of graduate students in physics, particularly those in solid state physics. Second, to provide a useful course covering the physics of a variety of solid state devices for students in several areas of physics. A secondary aim was the indication of several areas of current research in applied solid state physics.

II. Content of the Course

To achieve these ends, the course was designed to be a <u>survey</u> of the <u>physics</u> of a variety of solid state devices. As the italics indicate, the key words in the course description are physics and survey. Physics is a key word because the course tried to stress the physics of the various applications in an attempt to answer the following question. How does the solid state physics of the device result in its useful properties? An example was how the physics of the tunnel diode results in a negative dynamic resistance. The technology per se of the devices was not emphasized. To summarize, the aim of the course was the physics underlying the technology, rather than the technology itself.

The second key word was survey. The course was designed to be broad rather than deep, since, in one quarter, only the most important aspects of any subject could be touched upon. The survey nature of the course is reflected in the choice of topics given in the outline following. This choice is a compromise between the overwhelming importance of semiconductor devices and a desire for breadth of coverage. To this end, approximately two-thirds of the course was devoted to semiconductor devices. The remaining third was divided about evenly between magnetic, superconducting, and non-linear optical devices.

COURSE OUTLINE

	Hours
I. Energy Bands and Semiconductor Physics	2
II. Physics of Semiconductor Devices	18
1. Physics of p-n junctions	
2. Junction devices: diodes, transistors	
3. Negative resistance devices: tunnel diodes, Gunn effect	
4. Metal-semiconductor junctions	
5. Field effect transistors: JFET and IGFET	
6. Charge coupled MIS devices	
7. Detectors of electromagnetic radiation	
8. Luminescent devices and solid state lasers	
9. Surface physics and photoemission	
10. Amorphous semiconductors	
III. Magnetic Devices	3
1. Review of fundamentals: ferromagnetism; ferrites	
2. Magnetic bubble domains	
3. Ferrite microwave devices	
IV. Devices based on Non-Linear Optical Properties of Solids	3
1. Basic properties: non-linear polarization in crystals	
2. Second harmonic generation; phase matching	
3. Electro-optic modulation of light	
V. Superconductive Devices	3
1. Review of basic material; the Josephson effect	
2. Flux quantization and superconducting quantum interference	
3. Device applications of the Josephson effect	

As the outline shows, there were 29 one-hour lectures, including some material of a review nature. The latter material was included to make the course approximately self-contained.

There is presently no single textbook covering all of the material contained in the course outline. For this reason, lecture notes were written and distributed to the students. An extensive bibliography of references at several levels provided alternate treatments and more advanced material for those students who wished to read further on a particular topic. These lecture notes (340 typed pages) contain somewhat more material than can be covered comfortably in 30 lectures.

III. Student Response

From the students (both registered and auditors) who attended the lectures during the two years the course was given, several conclusions may be drawn concerning the student response to the course. During the Spring Quarter 1973, the course was given for the first time, and it attracted about 60 regular attendees, ranging from first-year graduate students to faculty members. Of special interest is the fact that 90 sets of lecture notes were distributed, thereby reaching a number of persons who did not attend the lectures. The second time the course was given (Spring Quarter 1974), the attendance was about 20 students, suggesting that much of the interest in the topic had been satisfied the previous year. In both years, the majority (60-80%) of the audience was physics graduate students, both in solid state and in other fields. There was also a large number of electrical engineering graduate students; the remainder of the class made up of students from chemistry and materials science.

IV. Conclusions

Based on the experience described above, it has been concluded that a course in applied solid state physics of this kind is of interest to a broad range of physics graduate students, as well as to students in engineering. It may also be noted that, in a course of this kind in which there is no single text presently available, distribution of lecture notes proved very useful to the students.

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