

# Semiconductor Technology

Programme course

12 credits

Halvledarteknik och tillverkning

TNE058

Valid from: 2019 Spring semester

**Determined by**

Board of Studies for Electrical  
Engineering, Physics and Mathematics

**Date determined**

2018-08-31

## Main field of study

Electrical Engineering, Applied Physics

## Course level

Second cycle

## Advancement level

A1X

## Course offered for

- Electronics Design Engineering, M Sc in Engineering

## Entry requirements

Note: Admission requirements for non-programme students usually also include admission requirements for the programme and threshold requirements for progression within the programme, or corresponding.

## Prerequisites

The students attending this course should have basic knowledge in physics and mathematics. The student should be able to solve system of equations, differential equations and have good knowledge in differential and integral calculus. Student should have basic knowledge in Newtonian mechanics and classical physics, electromagnetism, optics and wave. It is expected that the student have some knowledge from modern physics and can use Shrödinger equation on simple systems

## Intended learning outcomes

The aim of the course is to present the fundamental principle of semiconductor devices and how models of devices can be created from this understanding. How the semiconductor devices are fabricated? Basic unit processes will be presented. The students get the basic knowledge that is necessary to understand, work and produce integrated circuits and optoelectronics. After this course the student should

- Describe manufacturing steps, lithography, oxidation, metallization, and etching.
- Integrate the manufacturing steps for manufacturing of bipolar transistors, MOSFET, CMOS and MEMS.
- Explain the terms, band gap, energy level, mobility, effective mass, charge generation and recombination, doping, drift, diffusion, equilibrium and steady state.
- Apply relations between band gap, energy level, mobility, effective mass, charge generation and recombination, doping, drift, diffusion, conductivity, current density, temperature and illumination in semiconductors.
- Calculate and determine the material parameters (band gap, doping, level, carrier lifetime, diffusion length) from electrical characteristics of semiconductor devices.
- Design pn-junctions, Schottky diodes, bipolar transistor, MOSFET, and pn-solar cells having given characteristics.
- Design pn-junctions, Schottky diodes, bipolar transistor, and MOSFET.

## Course content

Basic semiconductor physics, concept and mechanisms such as band diagram, valence- and conduction band, Fermi level, Fermi-Dirac statistics, band gap, effective mass, drift, diffusion, doping, intrinsic, extrinsic, electron-hole pair, charge generation and recombination, minority carriers, majority carriers etc. will be discussed thoroughly. Function and modelling of pn-junctions, contact potential, depletion region, and different break down mechanisms for pn-junctions will be explained. Functions and I-V characteristics of some other devices such as MOSFET and bipolar transistors will also be discussed. Basic unit processes such as ion implantation, diffusion, thermal oxidation, annealing, deposition processes such as evaporation, sputtering, CVD, epitaxial growth, fabrication processes such as optical and non-optical lithography, photoresist and etching will be introduced. The students should enter deeply into one of the subjects below and present their work for the whole class. Device isolation, Contacts and metallization, CMOS technology, GaAs technology, bipolar technology and MEMS. Laboratory assignment includes classical labs with diode and transistor measurements.

## Teaching and working methods

Lectures and tutorial. Laboratory work, Weekly Home assignment , Student oral presentations. Mandatory attendance of some lectures and during student presentations.

The course runs over the entire autumn semester.

## Examination

UPG2	Optional assignments	0 credits	U, G
DUG1	Midterm Short Exam	2 credits	U, G
UPG1	Assignment, Written and Oral Presentation	1 credits	U, G
LAB1	Laboratory work	1 credits	U, G
TEN1	Written Examination	8 credits	U, 3, 4, 5

Mandatory attendance during student presentations

## Grades

Four-grade scale, LiU, U, 3, 4, 5

## Other information

Supplementary courses: Solar Cell Technology, Power Electronics, and Charge Transport in Organic and Inorganic Materials, System Design.

## Department

Institutionen för teknik och naturvetenskap

## Director of Studies or equivalent

Adriana Serban

## Examiner

Amir Baranzahi

## Course website and other links

<http://www2.itn.liu.se/utbildning/kurs/index.html?coursecode=TNE058>

## Education components

Preliminary scheduled hours: 108 h

Recommended self-study hours: 212 h

## Course literature

### Books

Jasprit Singh, (2004) *Semiconductor Devices, basic principles*  
ISBN: 0-471-36245-X  
Wiley & Sons

## Common rules

### Course syllabus

A syllabus has been established for each course. The syllabus specifies the aim and contents of the course, and the prior knowledge that a student must have in order to be able to benefit from the course.

### Timetabling

Courses are timetabled after a decision has been made for this course concerning its assignment to a timetable module. A central timetable is not drawn up for courses with fewer than five participants. Most project courses do not have a central timetable.

### Interrupting a course

The vice-chancellor's decision concerning regulations for registration, deregistration and reporting results (Dnr LiU-2015-01241) states that interruptions in study are to be recorded in Ladok. Thus, all students who do not participate in a course for which they have registered must record the interruption, such that the registration on the course can be removed. Deregistration from a course is carried out using a web-based form: [www.lith.liu.se/for-studenter/kurskomplettering?l=sv](http://www.lith.liu.se/for-studenter/kurskomplettering?l=sv).

### Cancelled courses

Courses with few participants (fewer than 10) may be cancelled or organised in a manner that differs from that stated in the course syllabus. The board of studies is to deliberate and decide whether a course is to be cancelled or changed from the course syllabus.

### Regulations relating to examinations and examiners

Details are given in a decision in the university's rule book:  
<http://styrdokument.liu.se/Regelsamling/VisaBeslut/622678>.

### Forms of examination

#### Examination

Written and oral examinations are held at least three times a year: once immediately after the end of the course, once in August, and once (usually) in one of the re-examination periods. Examinations held at other times are to follow a decision of the board of studies.

Principles for examination scheduling for courses that follow the study periods:

- courses given in VT1 are examined for the first time in March, with re-

examination in June and August

- courses given in VT2 are examined for the first time in May, with re-examination in August and October
- courses given in HT1 are examined for the first time in October, with re-examination in January and August
- courses given in HT2 are examined for the first time in January, with re-examination at Easter and in August.

The examination schedule is based on the structure of timetable modules, but there may be deviations from this, mainly in the case of courses that are studied and examined for several programmes and in lower grades (i.e. 1 and 2).

- Examinations for courses that the board of studies has decided are to be held in alternate years are held only three times during the year in which the course is given.
- Examinations for courses that are cancelled or rescheduled such that they are not given in one or several years are held three times during the year that immediately follows the course, with examination scheduling that corresponds to the scheduling that was in force before the course was cancelled or rescheduled.
- If teaching is no longer given for a course, three examination occurrences are held during the immediately subsequent year, while examinations are at the same time held for any replacement course that is given, or alternatively in association with other re-examination opportunities. Furthermore, an examination is held on one further occasion during the next subsequent year, unless the board of studies determines otherwise.
- If a course is given during several periods of the year (for programmes, or on different occasions for different programmes) the board or boards of studies determine together the scheduling and frequency of re-examination occasions.

### **Registration for examination**

In order to take an examination, a student must register in advance at the Student Portal during the registration period, which opens 30 days before the date of the examination and closes 10 days before it. Candidates are informed of the location of the examination by email, four days in advance. Students who have not registered for an examination run the risk of being refused admittance to the examination, if space is not available.

Symbols used in the examination registration system:

\*\* denotes that the examination is being given for the penultimate time.

\* denotes that the examination is being given for the last time.

### **Code of conduct for students during examinations**

Details are given in a decision in the university's rule book:  
<http://styrdokument.liu.se/Regelsamling/VisaBeslut/622682>.

### **Retakes for higher grade**

Students at the Institute of Technology at LiU have the right to retake written examinations and computer-based examinations in an attempt to achieve a higher grade. This is valid for all examination components with code "TEN" and "DAT". The same right may not be exercised for other examination components, unless otherwise specified in the course syllabus.

### **Retakes of other forms of examination**

Regulations concerning retakes of other forms of examination than written examinations and computer-based examinations are given in the LiU regulations for examinations and examiners,

<http://stydokument.liu.se/Regelsamling/VisaBeslut/622678>.

### **Plagiarism**

For examinations that involve the writing of reports, in cases in which it can be assumed that the student has had access to other sources (such as during project work, writing essays, etc.), the material submitted must be prepared in accordance with principles for acceptable practice when referring to sources (references or quotations for which the source is specified) when the text, images, ideas, data, etc. of other people are used. It is also to be made clear whether the author has reused his or her own text, images, ideas, data, etc. from previous examinations.

A failure to specify such sources may be regarded as attempted deception during examination.

### **Attempts to cheat**

In the event of a suspected attempt by a student to cheat during an examination, or when study performance is to be assessed as specified in Chapter 10 of the Higher Education Ordinance, the examiner is to report this to the disciplinary board of the university. Possible consequences for the student are suspension from study and a formal warning. More information is available at <https://www.student.liu.se/studenttjanster/lagar-regler-rattigheter?l=sv>.

### **Grades**

The grades that are preferably to be used are Fail (U), Pass (3), Pass not without distinction (4) and Pass with distinction (5). Courses under the auspices of the faculty board of the Faculty of Science and Engineering (Institute of Technology) are to be given special attention in this regard.

1. Grades U, 3, 4, 5 are to be awarded for courses that have written examinations.
2. Grades Fail (U) and Pass (G) may be awarded for courses with a large degree of practical components such as laboratory work, project work and group work.

### **Examination components**

1. Grades U, 3, 4, 5 are to be awarded for written examinations (TEN).
2. Grades Fail (U) and Pass (G) are to be used for undergraduate projects and other independent work.



3. Examination components for which the grades Fail (U) and Pass (G) may be awarded are laboratory work (LAB), project work (PRA), preparatory written examination (KTR), oral examination (MUN), computer-based examination (DAT), home assignment (HEM), and assignment (UPG).
4. Students receive grades either Fail (U) or Pass (G) for other examination components in which the examination criteria are satisfied principally through active attendance such as other examination (ANN), tutorial group (BAS) or examination item (MOM).

The examination results for a student are reported at the relevant department.

### **Regulations (apply to LiU in its entirety)**

The university is a government agency whose operations are regulated by legislation and ordinances, which include the Higher Education Act and the Higher Education Ordinance. In addition to legislation and ordinances, operations are subject to several policy documents. The Linköping University rule book collects currently valid decisions of a regulatory nature taken by the university board, the vice-chancellor and faculty/department boards.

LiU's rule book for education at first-cycle and second-cycle levels is available at [http://styrdokument.liu.se/Regelsamling/Innehall/Utbildning\\_pa\\_grund-\\_och\\_avancerad\\_niva](http://styrdokument.liu.se/Regelsamling/Innehall/Utbildning_pa_grund-_och_avancerad_niva).