

MS ISEE Study Track: Solar Cell Systems and Materials

Study plan and Course Table: 2017/2018

Year 1 at DTU: DTU Management Engineering, Associate Professor Lise-Lotte Pade

Year 2 at NTNU: Department for Material Science and Engineering Associate Professor Marisa Di Sabatino Lundberg

Study track focus and goals

The overall goal of the study track is to educate MSc level candidates with theoretical knowledge and practical competence, qualified to a professional career in the PV industry, or for PhD level studies in the field. The study track focuses on the fundamental principles behind- and the application and development of- photovoltaic materials and/or devices, and systems. The students will, based on bachelor background, have the opportunity to choose between a physics direction and a materials science direction.

In the first year at DTU, a broad basis in energy systems, technology and economics will be offered to all students. The fundamentals of solar energy harvesting are provided, in addition to basic courses in semiconductor physics and materials synthesis.

In the second year at NTNU, depending on study line/direction, advanced courses in solid state physics, optics etc. will be offered to students in the physics direction. For students in the materials science direction, courses covering process metallurgical, electro-chemical and chemical methods to synthesize semiconducting and light harvesting PV materials are offered. In addition, courses in PV Si-materials processing such as crystallization, wafering and passivation are available. The year at NTNU contains a 15 ECTS project, in addition to the 30 ECTS MSc project. Depending on project and MSc direction, course choice will be recommended by project supervisor.

Course Table

1. Semester	2. Semester	3. Semester	4. Semester
Technical University of Denmark (DTU) Search the course number (i.e.42002)		Norwegian University of Science and Technology (NTNU) Search for courses	
Modelling and Analysis of Sustainable Energy Systems Modelling using Operations Research, 42002, 5 ECTS	Chose 30 ECTS of Elective courses list 1 (Physics line) or 2 (Materials line)	Elective course list 3 (Physics line) or Elective course list 4 (Materials line) 7.5 ECTS	TFY 4915 Solar Cell Systems and Materials, Master's Thesis 30 ECTS (Physics line) or TMT 4915 Solar Cell Systems and Materials, Master's Thesis 30 ECTS (Material line)
Energy Economics, Markets and Policies, 42003, 10 ECTS		Elective course list 3 (Physics line) or Elective course list 4 (Materials line) 7.5 ECTS	
Feasibility Studies of Energy Technologies 42004, 5 ECTS (recommended) or Energy and Sustainability 28870, 5 ECTS,		TFY 4530 Solar Cell Systems and Materials Specialization Project 15 ECTS (Physics line), or TMT 4520 Solar Cell Systems and Materials, Specialization Project 15 ECTS (Material line)	
Analytical Imaging of Energy Materials by Electron Microscopy, 47311, 5 ECTS			
Light emitting diodes and photovoltaics for energy applications, 34540, 5 ECTS, or 11128 Development of solar energy systems, 5 ECTS			
= 30 ECTC	= 30 ECTS	= 30 ECTS	= 30 ECTS

Elective course list 1 - Physics line, DTU

- **January:** Experimental Techniques in Quantum Technology. 10386, 5 ECTS
- **January:** Hands-on microcontroller programming, 31070, 5 ECTS
- **Spring:** Solar heating systems, 11117, 10 ECTS
- **Spring:** Electronic Structure Methods in Material Physics, Chemistry and Biology, 10302, 10 ECTS
- **Spring:** *Nanophotonics, 34051, 10 ECTS**
- **Spring:** Exergy Analysis, 47317, 5 ECTS
- **Spring:** High Power Electronics, 31756, 10 ECTS
- **Spring:** Power system balancing with large scale wind power, 46230, 5 ECTS

**Requires Bachelor in Physics*

Elective course list 2 - Materials line, DTU

- **Spring:** Applied Inorganic Chemistry, 47303, 5 ECTS
- **Spring:** Electrochemistry, 47305, 5 ECTS
- **Spring:** Catalysis and Sustainable Chemistry, 26510, 10 ECTS
- **Spring:** Emerging Energy Technologies, 31778, 5 ECTS
- **Spring:** Functional Materials, 47319, 5 ECTS
- **Spring:** Ceramic Science and Engineering, 47304, 10 ECTS
- **Spring:** Electronic Structure Methods in Material Physics, Chemistry and Biology, 10302, 10 ECTS

Elective course list 3 - Physics line, NTNU

Depending on background, one can for example choose:

- **Fall:** TFE4145 Semiconductor Physics and Electronic Devices, Introduction 7.5 ECTS
- **Fall:** TFY4300 Energy and environmental Physics 7.5 ECTS
- **Fall:** FY3114 Functional Materials 7.5 ECT
- **Fall:** TFY4255 Materials Physics 7.5 ECT
- **Fall:** TMT4322 Solar Cells and Photovoltaic Nanostructures 7.5 ECTS

Elective course list 4 – Materials direction NTNU

- **Fall:** TMT4330 Resources, energy and environment 7.5 ECTS
- **Fall:** TMT4326 Refining and Recycling of Metals 7.5 ECTS
- **Fall:** TMT4322 Solar Cells and Photovoltaic Nanostructures 7.5 ECTS

Research areas for projects / master thesis

NTNU, Responsible prof., department	DTU, Second supervisor, department	Research area Topic (P= Physics line, M=Materials line)
Gabriella Tranell Merete Tangstad Department of Material Science and Engineering	Possible second supervisor, university, department (someone in chemical engineering)	<u>Si feedstock (M)</u> Si production and SoG-Si Refining
Marisa Di Sabatino Lundberg Lars Arnberg Eivind Johannes Øvrelid Department of Material Science and Engineering	Possible second supervisor, university, department	<u>Crystallization (M)</u> Material properties Characterization Wafering
Mari-Ann Einarsrud Fride Vullum-Bruer Department of Material Science and Engineering	Possible second supervisor, university, department	<u>Wet chemistry/sol gel (M)</u> TCO, nanoparticles Intermediate band materials
Turid W. Reenaas Ursula Gibson Randi Holmestad Ton Helvoort Morten Kildemo Mikael Lindgren Ingve Simonsen, Department of Physics	Possible second supervisor, university, department	<u>Thin film/third generation solar cells (P)</u> Intermediate band solar cells Thin film/Intermediate band solar cells TEM characterization TEM characterization Optical characterization Optical characterization Modeling light/matter interaction
Bjørn-Ove Fimland Helge Weman Department of Electronics and Telecommunications	Possible second supervisor, university, department	<u>III-V solar cells (P)</u> Nanowire and intermediate band solar cells Nanowire solar cells

Degree requirements for admission process

A BSc degree corresponding to a minimum of 180 ECTS credits in the following fields: Physics or relevant BSc (Physics line), Material Science or Inorganic Chemistry/Chemical Engineering (Materials line). Applicants must document that they have fulfilled the following minimum requirements:

Both lines

- Mathematics: 25 ECTS including linear algebra, calculus and differential equations
- Statistics and probability theory: 5 ECTS

Numerical methods and elementary programming using e.g. MATLAB or a similar programming language

Physics line

- Physics: 80 ECTS
- Mathematics and statistics: 60 ECTS

The university courses should cover curricula at a level comparable to that required for admittance to the graduate programme in physics at NTNU. As admission is extremely competitive, applicants should have excellent academic records (minimum B+/upper second/GPA 3.3/4).

Materials line

- Chemistry: 15 ECTS
- Thermodynamics: 7.5 ECTS
- Materials Science: 15 ECTS
- Mass and heat transfer: 7.5 ECTS