M.Sc. in Nano Technology with specialisation in Nano Physics and Nano Materials

- ***Education in the least!***

Nanotechnology is all about designing, fabricating and controlling materials, components and machinery with dimensions on the nanoscale, i.e. from 0.1 to 100 nm.

By constituting materials atom by atom or molecule by molecule it is possible to obtain decisive control over the properties and thereby construct unique materials with new and unexpected properties for applications within communication, data storage and -processing, (Bio)sensors, catalysis or medicine just to mention a few areas.

There are many challenges in nanotechnology and the area is very interdisciplinary. It is necessary to bring together expertise within physics, chemistry, biology, mathematics and materials science. Future engineers who hold an interdisciplinary education are therefore invaluable to solve the many challenging materials problems present on the nanoscale.

At the Department of Physics and Nanotechnology, Aalborg University we offer a unique education in nanotechnology with special focus on two areas, namely nanophysics and solid materials on the one side and nano biotechnology on the other.

Our students are taught in an innovative, dynamic and challenging environment through a combination of research-based courses, team-based project work and a high degree of interaction with industrial partners. We offer state of the art laboratory facilities including a class 100 clean room holding modern equipment for micro and nano scale fabrication and characterisation nanolab.aau.dk. Furthermore, a new well-equipped bio-chemistry lab including a class 1 area and state-of-the-art biophysical investigation equipment is available.

M.Sc. Specialisation: Nano Physics and Nano Materials

As a Master of Science in nano physics and materials, you have obtained the following:

Knowledge

Based on state-of-the-art international research within nanotechnology, especially physical, optical and electrical aspects, including synthesis and characterisation of structures, optic electronics, semiconductor physics, polymeric and composite materials and nano electronics.

Skills

You will master the scientific methods in nano biotechnology, and you will obtain general skills within problems associated with nano biotechnology.
You will be able to assess and choose among the scientific methods and theories for outlining new models for analysis and solutions.
You will be able to communicate research-based knowledge and discuss professional and scientific problems with both academic and laymen.

Competences

You will be able to control complex and unpredictable work- and development situations which presuppose new solutions.
You will be able to start and follow through academic and cross-disciplinary cooperation on an independent basis, and you will be able to take on professional responsibility.

Course overview:

Semester	Project theme	Courses	ECTS in all
NFM1	Synthesis and characterisation	Optoelectronics	30
		Semiconductor physics	
		Synthesis and characterisation	
		Continuum Mechanics	
		Laboratory Course in Organic Chemistry	
NFM2	Functional nano structures	Nano optics	30
		Polymer Chemistry – Synthesis and Modification	
		Self-organised bio structures	
		Surface physics	
		Polymers and Composite Materials	
NFM3	Advanced application of nano technology	Nano electronics	30
NFM4	Master's Thesis		30

Description of Courses

Optoelectronics
3 ECTS points.

Prerequisites: The course is based on the B.Sc. programme or comparable prerequisites.

Purpose: For the student to obtain an overview of various optical effects in materials and their applications.

Background: Optoelectronic applications of nanotechnology, including among others components applied in optical communications such as modulators, wave guides and lasers.

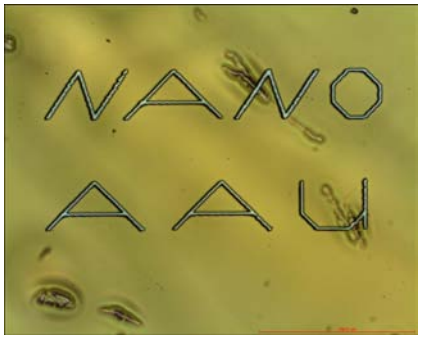
Aim: Upon the course, the student is able to:

- Account for the included concepts and methods
- Apply methods and tools to concrete problems

Content: The optical characteristics of materials, including optical activity and electro-, acoustics- and magnet optics. Optoelectronic components and their application, including the production principles and detection of radiation with examples from modern lasers and detectors.

Semiconductor Physics
3 ECTS points.

Prerequisites: Courses in quantum mechanics and electrical structure of solid state and nano structures or comparable.



Purpose: To impart to the student understanding of the physical principles of semiconductors and their application and to explain the function of important electronic and optoelectronic semiconductor components.

Background: Semiconductors are used in production of important components such as transistors. Hence, it is essential to know the characteristics of semiconductors and understand the function of semiconductor components.

Aim: Upon the course, the student is able to:

- Account for the included concepts and methods and the special characteristics of semiconductors
- Account for the function of important semiconductor components.

Content: Electrons in periodical structures and ribbon structures for semiconductors. The crystal structure and characteristics of various semiconductors, including silicon and III-V semiconductors. Acceptor and donor contamination. The dynamics and statistics of charge carriers. P-N diodes and metal-oxide semiconductor structures.

Synthesis and Characterisation
3 ECTS points.

Prerequisites: B.Sc. in Nanotechnology or comparable.

Purpose: For the student to obtain knowledge of synthesis and nano materials as well as characterisation of these. “Bottom-up” as well as “top-down” methods will be reviewed.

Background: Characterisation of nano materials involves a very wide spectrum of analytical methods. The overall part includes characterisation of both the geometric and electronic structure. The electronic determination of structure via optical spectroscopy methods. Direct depictions of nano materials may take place via various forms of microscopy such as optical microscopy, electron microscopy and AFM. These methods are reviewed during the course.

Aim: Upon the course, the student is able to:

- Apply basic techniques for geometric characterisation of nano structures
- Produce and characterise thin coats
- Structure surfaces via electron spectroscopy

Content: The course includes both theory and practical experiments. There will be a basic review of the physical and chemical principles as well as the application of such methods. Concerning synthesis, production of thin coats is reviewed via various evaporation methods, molecular beam epitaxy (MBE) and sputtering. Also introduced are experimental conditions – clean facilities, vacuum technology etc. – for syntheses.

The following subjects are included:

- Production of thin coats
- Physical vapour deposition
- Chemical vapour deposition
- Molecular beam epitaxy (MBE)
- Sputtering
- E-beam writing
- Optical microscopy, electron microscopy and nuclear power microscopy

Continuum Mechanics
5 ECTS points.

Prerequisites: B.Sc. in Nanotechnology or comparable.

Purpose: For the student to obtain knowledge of spatial deformation states when the geometric, dynamic/static and constructive conditions are met. Furthermore, the student is to obtain:

- Basic understanding of mathematical modelling of viscous elasticity and plasticity
- The ability to apply simple mathematical models for description of such phenomena in isotropic materials.

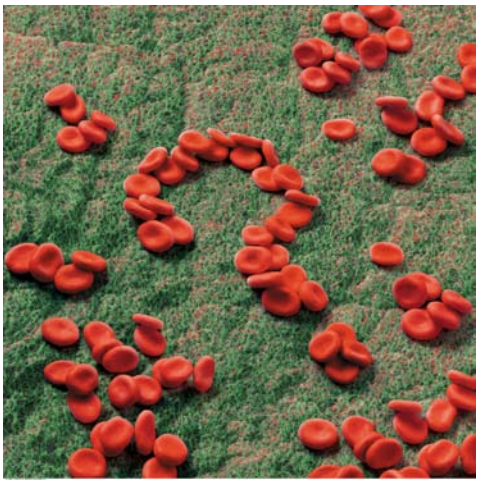
Background: The course introduces concepts and principles basic for understanding the following courses. Viscous elasticity and plastic materials' behaviour applies to a large proportion of the materials with which engineers work.

Aim: Upon the course, the student is able to:

- Demonstrate understanding of tensors and three-dimensional deformation- and voltage conditions
- Document knowledge of the introduced concepts and theories within the field
- Apply mathematical models for description of elasticity, viscous elasticity and plasticity to concrete problems
- Apply the correct academic terminology.

Content: The course includes the following subjects:

- A brief introduction to Cartesian tensors
- The deformation state
- Derivation of the strain tensor
- Principal strains
- Compatibility equations
- Derivation of the voltage tensor
- Equations of equilibrium
- Principal voltages
- The connection between strains and voltages for linear elastic, homogenous and isotropic materials – Hooke's Law
- Elastic strain energy
- Basic viscous elasticity.



Laboratory Course in Organic Chemistry

Prerequisites: Course in organic chemistry or comparable.

Purpose: To introduce the student to advanced techniques in experimental organic synthesis.

Aim: Upon the course, the student is able to:

- Work safely in a organic chemistry lab
- Design 'multiple-step' reactions for synthesis of specific combinations
- Operate commonly occurring equipment for organic synthesis
- Apply various techniques for organic synthesis
- Apply general separation- and cleaning methods
- Characterise the structure and purity of organic products.

Content: The prevalent techniques from preparative organic chemistry. Multiple-step reactions will be conducted, and separation- and cleaning methods will be reviewed, among others distillation, extraction, re-crystallisation, sublimation, thin coat and column chromatography. Methods for test identification/analysis include among others melting point determination, optical index, IR, UV/Vis and NMR spectroscopy. Part of the course may be used for the chemistry and biochemistry natural materials (enzymatic synthesis).

Nano Optics
5 ECTS points.

Prerequisites: Courses in electro magnetism and optics or comparable.

Purpose: For the student to obtain knowledge of nano optical components, light emission and light emission in nanoscale surroundings as well as the underlying theory and theoretical methods.

Background: Optical nano structures are applied in for instance telecommunications (optic fibres), filters/signal processing, resonators, dielectric mirrors in lasers and sensors based on resonant field enforcement. Moreover, rapid development is taking place within nano optic components due to modern production methods in the electronics industry and the in development of sound theoretical (numerical) methods.

Aim: Upon the course, the student is able to:

- Account for the function of significant nano optic components
- Account for the underlying theory and methods for analysis and design of nano optic components

Content: Planar optic components, optic wave guides, photonic crystals, metallic nano structures, surface plasmones, resonators and optic antennas, emission of light from sources in nano scale surroundings, theoretical methods in nano optics; for instance multiple method, spectral (plane-wave) methods and propagator methods.

Polymer Chemistry – Synthesis and Modification
3 ECTS points.

Prerequisites: Organic chemistry.

Purpose: For the student to obtain broad knowledge of polymer chemistry, including principles for polymerisation, theory of polymer crystallisation, polymer morphology, polymer characteristics etc.

Aim: Upon the course, the student is able to:

- Demonstrate understanding of various principles of polymerisation
- Design synthetic routes for functional polymerisation principles
- Conduct polymerisation under various conditions
- Modify polymer surfaces
- Characterise macro molecules; from chemical structure to molecular scale and partition

Content:

- Basic principles: molecular scale and polymer dissolutions
- Chemical structures and polymer characteristics
- Polymer morphology and –crystallisation
- Polymerisation via free radicals

- Ionic polymerisation
- Vinyl polymerisation with complex coordinating catalysts
- Characterisation of polymers, polythenes, sulphides and related polymers, polyamides and related polymers
- Heterocyclic polymers, various organic polymers
- Inorganic and partially inorganic polymers, natural polymers
- New developments within research of polymerisation techniques of new materials.

Surface Physics
5 ECTS points.

Prerequisites: Courses in statistical mechanics and electronic structure of solid materials and nanostructures or comparable.

Purpose: For the student to elaborate his/her insight into principles and methods from solid state physics and atomic and –molecular physics of solid materials' surfaces, and on thin coats.

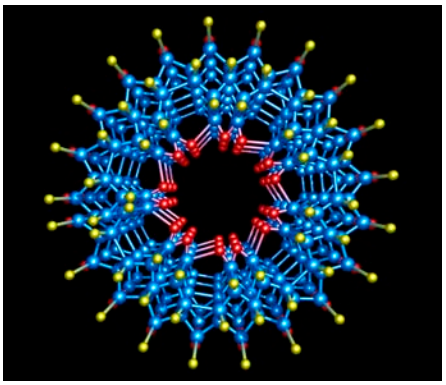
Background: Growth of nano structures and thin coats as well as chemical reactions all take place at the surface of solid materials. Hence, it is important to understand the basic physics of surfaces and applications relating to surfaces.

Aim: Upon the course, the student is able to:
- Account for the introduced concepts, theories and methods
- Apply methods and tools to simple objects and phenomena

Content: Growth phenomena in one, two and three dimensions are included. Epitaxy, diffusion, segregation and alloy formation. Electronic structure of surfaces, including absorption, desorption and reactions between adsorbents on surfaces (catalysis). Spectroscopic methods, electronic as well as optic, for characterisation of the electronic and geometric structures of surfaces are reviewed.

Polymers and Composite Materials
5 ECTS points.

Prerequisites: Organic chemistry, elasticity theory, continuum mechanics or comparable.



Purpose: For the student to obtain:
- The ability to make a qualified choice of materials, processing of polymers, dimensioning strained mechanical components of thermoplastic, construct products of thermoplastic and specify tolls for injection moulding of thermoplastic
- Basic knowledge of general principles and theories within the field of composite materials
- Understanding of the basic elements within classical analysis methods for interpretation of composite materials' structural behaviour

- The ability to analyse connections between composites' structural behaviour and outer forces based on classical methods of analysis.

Background: Polymers are widely applied, and this course provides the student with basic knowledge of polymers and their processing as well as basic knowledge of composite materials' modelling, analysis and production.

Aim: Upon the course, the student is able to:
- Choose polymer material and production process
- Dimension strained components of polymers
- Demonstrate knowledge of assembling methods in polymers
- Apply classical methods in the field of composite materials
- Analyse the mechanical behaviour of composite materials
- Assess the result of an analysis of composite materials.

Content: The course includes the following elements:
- Mechanical characteristics of polymers, viscous elasticity
- Processing of thermo – and harden plastic
- Assembling thermo- and harden plastic
- General introduction to composite materials
- Macro mechanical behaviour of lamina
- Micro mechanical behaviour of lamina
- Macro mechanical behaviour of laminate

Nano Electronics
3 ECTS points.

Prerequisites: Course in semiconductor physics or comparable.

Purpose: For the student to obtain knowledge of the background and funciton of semiconductors and nano electronic components based on low dimensional structures.

Background: Integrated electronics are already on the nano scale, and in the future, this development will continue. Moreover, new low dimensional structures are already attempted used in nano electronics.

Aim: Upon the course, the student is able to:
- Account for the introduced concepts and methods for simulation of low dimensional structures
- Account for the function of essential nano electronic components.

Content: Electronic characteristics of quantum wells and quantum wires. Methods for simulation of these characteristics. Application of one- and two-dimensional nano structures such as metal-oxide semiconductor transistors.

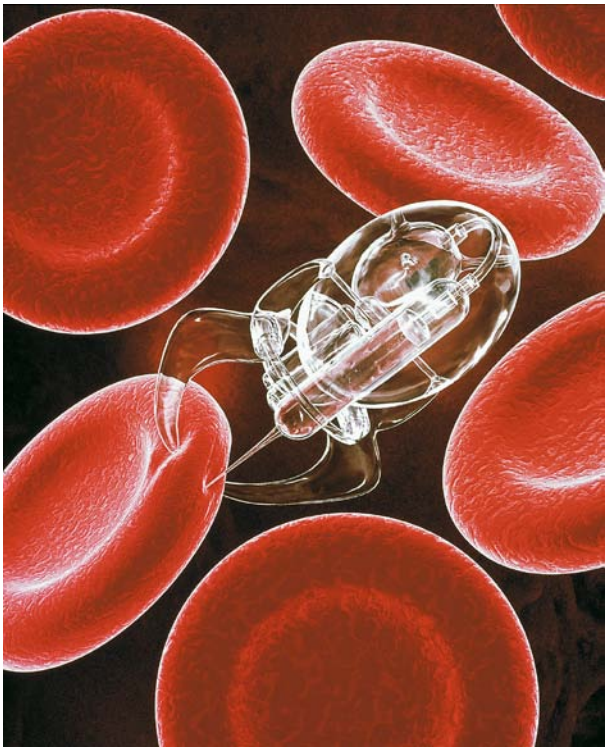
4th Semester M.Sc. Thesis.
30 ECTS points.

Purpose: The Master's Thesis is carries out as problem-oriented project work aiming towards:

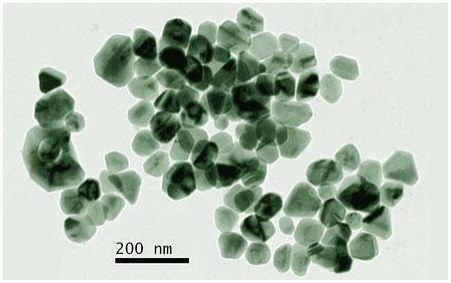
- The student attaining either specialist knowledge within a few chosen elements of the field
- Or broad insight into the field regarding its theories, methods and central elements and their internal relations
- Or relevant competences supplementing the given competence profile.

Aim: No matter the chosen aim, the student must be able to:

- Through independent, systematic and critical analysis be able to identify, formulate and analyse the chosen problem
- To relate the problem to the field of nano biotechnology, including accounting for the choices made when defining the problem
- Make and substantiate decisions for methods of scientific, theoretical and/or experimental character on an individual basis
- Critically be able to on an individual basis assess the chosen theories and methods on which the analyses, results and conclusions in the Thesis is based – both during the making of the thesis and after it is finished
- Communicate relevant academic and professional aspects of the work in a clear and systematic manner.



Admission
Admission to the Master Programme in Nanotechnology with specialisation in Nano Physics and Materials presupposes a relevant Bachelor of Science degree in natural sciences, materials science, or biotechnology.



All international applicants (Scandinavian students exempted) must document basic written and spoken English by taking a test. You must complete and pass one of the following:
The IELTS test (International English Language Testing System).
The TOEFL test (Test of English as a Foreign Language)
The Cambridge ESOL test (Examinations for Speakers of Other Languages)

International students may gain admission upon Aalborg University's assessment of the individual applicant.

More information
If you are interested in studying for your Master Degree in Nano Biotechnology, you are welcome to contact our International Office:

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We look forward to seeing you in Aalborg!