SDC

The university partnership
Denmark – China

Master's Programme in

Nanoscience and Technology

Curriculum

2017

Table of content

Legal Frame

Students enrolled in this programme are admitted as full-time students at University of Chinese Academy of Sciences.

This curriculum applies to students enrolled in the programme from 2017.

This master's programme is established within the framework of the following:

- Partnership Agreement between Graduate University of Chinese Academy of Sciences and University of Copenhagen (KU), Aarhus University (AU), University of Southern Denmark (SDU), Aalborg University (AAU), Roskilde University (RUC), Technical University of Denmark (DTU), Copenhagen Business School (CBS), IT University of Copenhagen (ITU), on the establishment of the Sino-Danish Centre for Education and Research, Graduate University of Chinese Academy of Sciences, signed on 12 April 2010
- Agreement between Graduate University of Chinese Academy of Sciences (GUCAS) and University of Copenhagen (KU), Aarhus University (AU), University of Southern Denmark (SDU), Aalborg University (AAU), Roskilde University (RUC), Technical University of Denmark (DTU), Copenhagen Business School (CBS), IT University of Copenhagen (ITU) concerning Master's Programmes at Sino-Danish Centre for Education and Research, Graduate University of Chinese Academy of Sciences, signed on 29 August 2011
- Agreement between Graduate University of Chinese Academy of Sciences and University of Copenhagen concerning Provision of the Master's Programme in Nanoscience and Technology at Sino-Danish Centre for Education and Research (SDC), Graduate University of Chinese Academy of Sciences, signed on 29 August 2011.

Students must observe and act accordingly to the following rules issued by the SDC Directors:

- Courses and Exams
- Exam regulations
- Thesis regulations 10 steps
- Avoid cheating on exams
- Student complaints

Students must also observe and act accordingly to Rules and Regulations for UCAS International Students.

SDC rules are published on Moodle.

Title and degree

The degree awarded by University of Copenhagen is Master of Science (MSc) in Nanoscience and Technology. The degree awarded by University of Chinese Academy of Sciences is Master of Nanoscience and Technology.

Duration

The master's programme has a duration of two academic year's equivalent to 120 ECTS points (European Credit Transfer System). 60 ECTS points correspond to one year of full-time studies.

When choosing thesis period *Danish/International students* must be aware of UCAS' four years limit for awarding diploma. UCAS' degree application procedure ***STEP 10 CN*** (see Thesis regulations 10 step) has to be completed within four years from enrolment. This period includes leave of absence.

Admission requirements

Admission to the Master's programme in Nanoscience and Technology is based on:

- A successfully completed bachelor's degree (or equivalent) or higher in a natural science field such as Nanoscience. Other bachelor's degree in a natural science such as chemistry, physics, biochemistry or material sciences.
- High-level English language proficiency (English level B).

General programme regulations

The language of instruction in the SDC master's programmes is English. Teaching, supervision and assessment will be carried out in English.

Students will be graded according to both the Chinese and the Danish grading scale. However, for the Master's Thesis, students will be graded according to the Chinese 4-point scale. See Thesis regulations 10 steps.

DK	12	10	7	4	02	00	-3
CN	100-95	94-9	89-76	75-61	60	59-40	39-0

Leave of absence can be granted to students on the grounds of becoming a parent, illness, military service or exceptional circumstances.

Students who wish to complete degree programme elements at another university or institution of higher education in Denmark, China or abroad as part of their degree programme may apply the Teaching Committee for advance approval of transfer credit for planned subject elements.

Students can maximum be granted 30 ECTS credit transfer.

Either the Teaching Committee or the SDC Directors may grant exemptions to this curriculum or other SDC rules. Application for exemption shall be submitted to the SDC Secretariat

Qualifications

The MSc programme in Nanoscience and Technology is an interdisciplinary, research-based study programme with focus on theoretical, experimental and practical disciplines. The programme enables students to handle nanoscience and nanotechnology concepts and methodologies and provides students with fundamental knowledge within business innovation and entrepreneurship. The programme recruits students from many different basic science subjects such as physics, chemistry, molecular biology and biology and from engineering programmes as well as BSc programmes in nanoscience. Common to these areas is that graduates of the MSc in Nanoscience and Technology programme have in-depth knowledge of the methodologies of the subject area and have applied these in specific projects, typically involving colleagues from other subject areas.

Graduates of the MSc programme in Nanoscience and Technology will be able to function as a link between specialists in, for example, physics and biology, and will be able to communicate technical and conceptual issues across the subject areas. Graduates of the MSc in Nanoscience and Technology programme will in particular have an eye for new and unconventional applications of natural science techniques and methodologies, based on the many specific examples taught on the study programme.

General competency description

Competences

Graduates of the MSc programme in Nanoscience and Technology have acquired are able to:

- formulate, structure and complete a research project involving development and application of the methodologies of the subject area.
- manage complex work and development situations in collaboration with other disciplines, such as physics, chemistry and biology
- on a scientific background, enter into constructive collaboration on solving academic issues within the fields of nanoscience and nanotechnology.
- seek out and summarise the knowledge available within a specific nanoscience field.
- assess the possibilities and limitations of the methodologies of the subject area.
- discuss the methodologies, theory and results of the subject area in general as well as at an academic level.

- assess the applicability and appropriateness of theoretical, experimental and practical methodologies of the results of the subject area in an industrial, social and ethical context on a nano scientific basis.
- independently plan, manage and complete projects and apply the results of these in an academically related decision-making process.
- systematically and critically familiarise themselves with new subject areas.
- independently and critically structure their own competency development.
- identify business opportunities and plan the establishment of a business.

Skills

Graduates of the MSc programme in Nanoscience and Technology have are able to:

- process and analyse data.
- analyse and solve academic questions and issues.
- set up and analyse theoretical models.
- read and understand original academic literature.
- use the most important databases within the subject area.
- disseminate and communicate nano scientific questions and academic issues to both academic and general audiences.
- develop business models.
- analyse the market for technological products and services, among other things in connection with the establishment of a business.

Knowledge

Graduates of the MSc programme in Nanoscience and Technology have acquired:

- general knowledge about current nanoscience trends and, based on the highest level of international research, detailed knowledge of key disciplines, methodologies, theories and concepts within one or more of the basic physics, chemistry, molecular biology and biology disciplines.
- basic knowledge of business innovation and entrepreneurship, enabling the graduate to develop and assess plans for the establishment of a business.
- the necessary knowledge and methodology within selected research active areas, through courses and project work.
- in-depth knowledge of a specialised field at international level, through independent research under supervision.

Structure

The programme contains these elements

Semester	Course / Programme element	Exam	Grading	Examiners	ECTS
1	Unifying Concepts in Nanoscience (UCN)	Assignment and oral	7/100 scale	Internal	15
	Nanobiotechnology	Written	7/100 scale	Internal	5
	Nanocharacterization	Written	7/100 scale	Internal	10
2	Nanoelectronics	Oral	7/100 scale	Internal	5
	Synthesis and Fabrication	Assignment and oral	7/100 scale	Internal	10
	Bionanomaterials	Assignment	7/100 scale	Internal	5
	Business Innovation and Entrepreneurship	Written	7/100 scale	Internal	5
	Nano Energy Materials	Written	7/100 scale	Internal	5
3	Thesis	Assignment and oral	7/4 scale	External	60
4					

Course and exam descriptions

Unifying Concept in Nanoscience

15 ECTS

CONTENT

Nanosized systems have special properties. The objective of the course is to learn about the unifying concepts that form the scientific basis of these special properties.

LEARNING OBJECTIVES

At the end of the course, the students should be able to:

The physical and chemical basis for the special properties of nanoscale systems will be developed systematically using the simplest possible models

EXAMINATION

Essay (34%), oral exam (33%), and assignments (33%). To qualify for the exam students, have to hand in 3 assignments during the course, present two research articles, and write a 15-page essay on a chosen topic. Oral exam 30 minutes without aids.

RE-EXAMINATION

Same as ordinary. The assignments and essay must be completed before the oral re-exam. If less than five students should take the re-exam the re-exam could be different than the ordinary exam.

GRADING

Grades are given according to the Danish 7 step and the Chinese 100 points grading scales

Nanobiotechnology

5 ECTS

CONTENT

This course introduces students to the selected areas in nanobiotechnology – the field which employs nanoscience for biomedical applications. The students will learn how artificial entities can support their biological counterparts. The course helps students to better understand health impacts and the risks of nanoscience and technology by obtaining an introduction to nanotoxicology. Further, microfluidic concepts and omics techniques for biomedical application will be addressed. For all topics, basic knowledge, key concepts and real experiments will be discussed.

LEARNING OBJECTIVES

This course will cover the following areas in nanobiotechology:

- General overview over basic biotechnological and nanobiotechnological concepts.
- Self-assembly
- Artificial enzymes, organelles and cells
- (Biological) Nanobots
- Nanotoxicology
- Microfluidics
- Omics

EXAMINATION

Compulsory report (25% of the grade) and written 48 h take home exams (75% of the grade) in the form of an essay. Aid is allowed. Internal censorship.

RE-EXAMINATION

Same as ordinary. The compulsory report must be completed before the re-exam. If less than five students should take the re-exam the re-exam could be different from the ordinary exam.

GRADING

Grades are given according to the Danish 7 step and the Chinese 100 points grading scales

Nanocharacterization

10 ECTS

CONTENT

In this course students will learn the basic physical principles behind a number of nanocharacterisation tools. Five main areas will be addressed in detail: Electron microscopy, X-ray diffraction, scanning probe microscopy, surface spectroscopies, and nuclear magnetic resonance. The first part of the course will introduce the theoretical background and implementation of the techniques as well as discuss application examples based on scientific literature. The last part of the course will involve hands-on exercises on a number of the techniques.

In the first five weeks of the course, the five main areas/techniques are covered through a combination of lectures, exercises, student discussions and student presentations. In the last two weeks experimental exercises are performed, typically in groups of three students. On average 10-12 hours of teaching per week.

LEARNING OBJECTIVES

At the end of the course the students should be able to introduce a number of essential methods for nanocharacterisation and to build the power to select and apply these methods to obtain specific information from given experimental systems.

EXAMINATION

Report/essay based on the experimental exercises. Written exam (three hours, without aides). The course grade is based both on the report (25%) and the written exam (75%). Internal censorship.

RE-EXAMINATION

Same as ordinary, report must be completed before the re-exam. If less than five students should take the re-exam the re-exam could be different from the ordinary exam.

GRADING

Grades are given according to the Danish 7 step and the Chinese 100 points grading scales

Nanoelectronics

5 ECTS

CONTENT

Electronic transport in nanostructures. The course will cover the following areas: concepts in electron transport, current flow in nanostructures, mesoscopic electron transport, the quantisation of charge, and conductance and their consequences for transport, Landauer (transmission) formalism. The chosen examples will include quantum wires, low dimensional semiconductor structures, quantum dots, graphene, carbon nanotubes, molecular transistors, and other timely subjects in nanoelectronics. One session will be devoted to nanofabrication.

The course also includes two laboratory experiments:

- Measurement of the Quantum Hall effect and Shubnikov de Haas oscillations in a two-dimensional electron gas at low temperatures (4 Kelvin).
- Fabrication (or measurements) of graphene quantum dots.

The experimental results are to be analysed in context of the theory presented in the course and summarised in reports written in groups of 3-4 students.

We aim at giving a phenomenological introduction to selected topics in the physics of nanostructures. The general theme is current flow (electron transport) in (low-dimensional) nanoscale structures, where quantum effects are expressed clearly. The basic formalism, key concepts and real experiments will be discussed, rather than complete theoretical treatments, which are covered in other courses. The students will be provided with the background for understanding a wealth of recent experiments in the field which ranges from quantum Hall physics, single-electron transport through "artificial atoms" in semiconductor structures to real "molecular transistors" based on single molecules. In addition to the purely scientific interest, these phenomena are also of technological importance in nanoelectronics and potential future applications in quantum information processing.

LEARNING OBJECTIVES

After completing the course, the student should be able to:

- demonstrate understanding of the basic formalism and the key concepts within electron transport.
- describe the differences between transport in bulk materials (metals, semiconductors) and nanostructures.
- explain the most prominent consequences of quantum effects in electron transport through nanostructures (limited to the contents of the course).
- describe the functionality of selected nanoelectronic devices based on these principles.

- differentiate between various regimes of mesoscopic electron transport.
- sketch the key elements in realising an electron transport experiment on a nanostructure.
- identify the relevant physical parameters in such an experiment, e.g. the essential length scales, energy scales, characteristic temperatures, quantized units etc.
- carry out experiments on simple experimental setups for measurements of nanodevices.
- know basic low-temperature techniques for measuring of nanodevices.
- apply theory from the course on experimental data to extract relevant parameters.
- write a report presenting relevant theory, experimental results and analysis.
- differentiate between ideal theoretical quantum phenomena and measurements under less ideal conditions.
- present clearly the phenomena reported in a research article within the field of experimental electron transport in nanostructures (in the following referred to as "the article").
- differentiate between the essential information and technical details in the article.
- reproduce and discuss the main features and trends in graphical representations of transport data.
- relate the findings to the theory treated in the course.
- relate or contrast to relevant examples (e.g. other articles) known from the course in order to demonstrate a broader understanding of the field.
- evaluate critically the article's conclusions to the extent that the background for this discussion has been treated in the course.

EXAMINATION

Oral examination (approx. 30 min), 10-12 minutes presentation based on one of the reports/experiments (A or B) followed by a discussion on other topics covered in the course.

RE-EXAMINATION

The same as the ordinary exam. The re-exam will be held as the ordinary exam, report (A or B) must be completed before re-exam. If less than five students should take the re-exam the re-exam could be different from the ordinary exam.

GRADING

Grades are given according to the Danish 7 step and the Chinese 100 points grading scales

Synthesis and Fabrication

10 ECTS

CONTENT

The course will be taught on the basis of recent reviews on the state-of-the-art nano-assembly and top-down/bottom-up nanofabrication. The student will learn different chemical methods used in construction of functional molecules and in surface and polymer modification as well as lithographic procedures for nanofabrication.

LEARNING OBJECTIVES

Nanomaterials are fabricated by utilising modern chemistry design, technology and techniques. The student will be made familiar with these synthetical techniques, chemical/physical methods to characterize the nanomaterials and enable their applications.

A student that fully meets the requirements of the course should be able to:

- Fabrication of self-assembled monolayers (ZMW)
- Single-molecule devices (ZMW)
- Organic electronics: OLED, OFET, OSC (ZMW)
- Novel nanoporous materials (BHH)
- Graphene, Chemical GO (BHH)
- Graphene, CVD, properties, characterization, application in devices (YQL)
- Polymer (RS)

EXAMINATION

Oral exam (60%) and assignments (40%). To qualify for the exam, students have to hand in all four assignments (teachers will hand out one each), present a research article and present part of an assignment during the course.

RE-EXAMINATION

Re-exam same as ordinary. Assignments must be completed before re-exam. If less than five students should take the re-exam the re-exam could be different from the ordinary exam.

GRADING

Grades are given according to the Danish 7 step and the Chinese 100 points grading scales

Bionanomaterials

5 ECTS

CONTENT

The aim of this course is to provide the students with background knowledge on bionanomaterials based on the assembly of nucleic acid, peptide and protein. To introduce the latest achievements in basic research and potential applications.

This course will go through themes such as: Self-assembly of biological molecules. Design and assembly principle of DNA and RNA nanostructures: build 3D nanostructures with controlled size and geometry. DNA based organic synthesis. Modification of nucleic acids nanostructures with various functional elements. Nucleic acids based imaging probes and drug delivery system. Artificial molecular devices. Construction of peptide assembly nanosctructures. Protein assembly nanostructures. Peptide assembly based nanomaterials. Biomedical application of peptide based nanomaterials. Disease associated peptide and protein assembly.

LEARNING OBJECTIVES

At the end of the course, the students should be able to:

- describe the basic concept of DNA and RNA nanotechnology; explain and compare different strategies to assemble DNA nanostructure; design DNA nanostructures with provided software relate models of designed nanostructures to fabrication of nucleic acids nanomaterials; explain the strategies to assemble metal nanoparticle for plasmonic study and encapsulate drug molecules for therapeutic purpose.
- read and give a short presentation of a scientific paper within the subject area, understand the basic concept of peptide and protein assembly.
- understand the interaction mechanism between peptides in peptide and protein assembly; describe the possible aggregation pathways in peptide assembly; explain the strategies to design peptide assembly nanostructures for biomedical applications.
- expose the above goals in a scientifically correct language.

EXAMINATION

A three day take-home assignment in the form of an essay. All students will be evaluated by their class performance/presentations and final essay scores. Internal censoring

RE-EXAMINATION

The re-examination is the same as ordinary. If less than five students should take the re-examination it can be different from the ordinary exam.

GRADING

Grades are given according to the Danish 7 step and the Chinese 100 points grading scales

Business Innovation and Entrepreneurship

5 ECTS

CONTENT

Taking into consideration that more natural sciences graduates will work in companies in real business contexts or start building new businesses as their career choices, this course will provide an introduction to main concepts and theories related to innovation, organisation, and entrepreneurship.

How to organise and manage technological activities is an important part of a high-velocity global market. To keep competitive advantage in such a dynamic global market, companies and organisations are required to change and develop continuously, i.e. work with innovation. On the other hand, to take advantage of the new global and technological opportunities, the existing firms reorganise to become more entrepreneurial which involves the spotting, developing, and pursuing of business opportunities, by creating innovative projects inside the companies.

The main subjects covered are:

- The concepts of innovation, entrepreneurship, and organisation.
- Organisation structure and design.
- Leadership and Intrapreneurship.
- Innovation project and management.

The course comprises lectures, cases, discussions and students' active involvement, and consists of three parts:

- The basics of innovation, entrepreneurship and organisation.
- Leadership, entrepreneurship and business model.
- Innovation project management.

For each part there will be 3-4 sessions of teaching, for each session there will be three teaching hours. The students are required to read and reflect on the literature and proactively engage in class discussions.

LEARNING OBJECTIVES

By the end of the course, the students are expected to relate nanotechnology knowledge and knowledge learned from this course to:

- understand and explain the concepts and principles of innovation, and identify different types of innovations.

- understand the concept of entrepreneurship, and be able to identify nanotechnology related business opportunities.
- design their own business models and organisations for new businesses.
- understand basic tools of project management, and apply to their own nanotechnology related innovation projects.

EXAMINATION

Individual written essay on the topic: Business innovation and entrepreneurship in a nanotechnology perspective.

Format:

- Min 5 pages, max 10 pages (including references, tables, and figures)
- Font 12, max. 2400 characters per page.
- The student is expected to formulate a problem, and use theories/frameworks/concepts learned in class to help explain/solve the problem.

RE-EXAMINATION

The re-exam will be held as the ordinary exam. If less than five students should take the re-exam the re-exam could be different from the ordinary exam.

GRADING

Grades are given according to the Danish 7 step and the Chinese 100 points grading scales

Nano Energy Materials

5 ECTS

CONTENT

This course sets out to explore:

- Description of fundamental concepts in the synthesis, physical properties, and applications of nanoenergy materials.
- Crystal structures and bonding in solids.
- Short introduction to X-ray diffraction and its use for analysis of crystalline materials.
- Interpretation and use of phase diagrams.
- Defects.
- The electrical and magnetic properties of solids and nanoparticles. Emphasis will be placed on relations between structure and properties.
- Surface energy of nanoparticles.
- Nucleation and growth theory.
- Nanoparticle interaction and synthesis methods.
- Applications of nanomaterials for energy applications.

LEARNING OBJECTIVES

At the end of the course, the students should be able to:

- explain basic nucleation and growth theory.
- explain nanoparticle interactions.
- elate surface physics and chemistry to nanoparticle morphology.
- relate nanoparticle morphology and size to its properties.
- explain the interrelationship between band structure and properties.
- explain basic phase diagrams and relate it to phase transformations in materials.
- explain the fundamental concepts of the following technologies, and the role and benefits of nanomaterials: thermoelectrics, photovoltaics, magnetic materials, supercapacitors, batteries, hydrogen storage materials.
- express the concepts above verbally in a scientifically clear, correct and engaging language.

EXAMINATION

Written exam: 3hour written exam + mandatory weekly assignments

RE- EXAMINATION

The re-examination is the same as ordinary. Assignments must be completed before re-exam. If less than five students should take the re-examination it can be different from the ordinary exam.

GRADING

Grades are given according to the Danish 7 step and the Chinese 100 points grading scales

Thesis

60 ECTS

CONTENT

The purpose of the thesis is to allow students to demonstrate their ability to work independently with an academic topic, which is an important part of the individual student's academic profile.

The thesis amounts to 60 ECTS credits. It must be of an experimental nature, i.e. they must contain the student's own production of academic work in the form of the generation of original data/original material.

Two supervisors will be appointed, one Chinese from CAS/UCAS and one Danish from a Danish University.

If the thesis is completed at an external institution (e.g. a company), the student will also be assigned an external supervisor from the external institution. The external supervisor from the external institution participates in the planning of the thesis studies in collaboration with the two supervisors.

The external supervisor does not participate in the defence or the grading.

Thesis contract

A thesis contract is completed at the start of the thesis work, which sets out the thesis framework content. The thesis contract is also an exam registration and must be signed by the student and the two supervisors. The supervisors are responsible for approving the problem formulation.

Before completing the thesis contract, the student and the supervisors are to agree a plan for the thesis supervision that covers issue. The plan should include the following: how often and how supervision is to be carried out, what is expected of the supervisors and the student at supervision meetings, conditions concerning the collection of primary data/experimental work, and general mutual expectations to the working relationship.

Deadline for submission

The supervisors are responsible for ensuring that the scope of the thesis is such that it can be completed within the set timeframe, and that the student receives regular feedback as to whether his/her work is progressing at a pace that will allow him/her to comply with the timeframe.

The deadline for submitting the thesis is 1 June when following the standard period.

The deadline for submission set out in the thesis contract is binding, and exceeding the deadline counts as an exam attempt.

LEARNING OBJECTIVES

A student who has completed the thesis has acquired the following competences:

Knowledge

Knowledge that allows the student to:

- identify scientific problems within the study programme's subject areas.
- summarise a suitable combination of methodologies/theories based on international research for use in his/her work with the problem formulation.
- discuss theories/models on the basis of an organised value system and with a high degree of independence.

Skills

Skills that allow the student to:

- apply and critically evaluate theories/methodologies, including their applicability and limitations.
- assess the extent to which the production and interpretation of findings/material depend on the theory/methodology chosen and the delimitation chosen.
- discuss academic issues arising from the thesis.
- draw conclusions in a clear and academic manner in relation to the problem formulation and, more generally, consider the topic and the subject area.
- discuss and communicate the academic and social significance, if any, of the thesis based on ethical principles.

If the thesis includes experimental content/data production, the student will also be able to:

- substantiate the idea of conducting experimental work/producing his/her own data in order to shed light on the topic as formulated in the problem formulation.
- process data through a choice of academic analysis methods and present findings objectively and in a concise manner.
- assess the credibility of his/her own findings based on relevant data processing.

Competences

Competences that allow the student to:

- initiate and perform academic work in a research context.
- solve complex problems and carry out development assignments in a work context.

EXAMINATION

The thesis is concluded with a two-part individual exam consisting of the preparation of a written thesis report and a subsequent oral presentation/defence of the thesis report. The oral defence must be held no later than two months after the submission of the thesis report, and the grade must be awarded on the same day as the thesis defence is held.

The thesis is assessed by the two supervisors and an external examiner, and a single grade is given for the thesis report and the oral defence. In addition to assessing the academic content of the thesis, where the abstract is included on a par with the other components, the examiners will also assess the student's spelling and writing proficiency.

If the student requests such, the main supervisor and the external examiner are, in connection with the assessment, to prepare a written academic and methodical evaluation, which is to be presented to the student no more than seven working days after publication of the grade.

Requirements for taking the exam

For the oral thesis defence to be held, a thesis report must have been handed in by the deadline.

The thesis report and its references make up the syllabus at the thesis exam.

Published theses, articles, peer-reviewed articles or manuscripts with several authors may be used either in the thesis report or as annexes, but only if (co-)author statements can be obtained which specify the scope of the student's contribution.

The thesis is concluded with an oral defence lasting approx. 60 minutes, including a presentation lasting approx. 30 minutes.

RE-EXAMINATION

The same as the ordinary.

GRADING

For the Danish/international students, grades are given according to the Danish 7 step and the Chinese thesis grading scales.

For the Chinese students, grades are given according to the Danish 7 step grading scale only.

The details of the thesis procedure are described in SDC Thesis Regulations 10 Steps.

Commencement

Effective as of 01.09.2017

Changes to the curriculum

No changes yet.