Master of Science
Green Electronics

At A Glance

JOINT DEGREE BY
Technical University of Munich (TUM)
Nanyang Technological University (NTU)

TWO-YEAR FULL TIME PROGRAMME
Coursework in Singapore

PRACTICAL KNOWLEDGE
Compulsory Internship & Thesis

GLOBAL PROSPECTS
Internationally Recognized Degree

INTAKE
August Every Year

TO APPLY
Apply online from 15th October at www.tum-asia.edu.sg

1 TUM is ranked as the #1 University in Germany+
1 NTU is ranked #1 in Asia for Engineering++
1 NTU is ranked #1 in the world for industry income and innovation*
8 TUM ranked #8 in the Global Employability Survey^*
50 Both TUM & NTU# are in the world’s Top 50 Universities

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Both TUM & NTU# are in the world’s Top 50 Universities

+ Source: Times Higher Education World University Rankings 2021
++ Source: Quacquarelli Symonds
* Source: Times Higher Education World University Rankings 2021
^ Source: Times Higher Education World University Rankings 2021
# Source:QS World University Rankings 2021
Technical University of Munich (TUM)

Technical University of Munich (TUM) is one of Europe's leading research universities, with around 500 professors, 10,000 academic and non-academic staff, and more than 40,000 students. Its focus areas are the engineering sciences, natural sciences, life sciences and medicine, reinforced by schools of management and education.

TUM acts as an entrepreneurial university that promotes talents and creates value for society. In that it profits from having strong partners in science and industry. It is represented worldwide with a campus in Singapore as well as offices in Beijing, Brussels, Cairo, Mumbai, and São Paulo.

Nobel Prize winners and inventors such as Rudolf Diesel and Carl von Linde have done research at TUM. In 2006 and 2012 it won recognition as a German “Excellence University.” In international rankings, TUM regularly places among the best universities in Germany.

Nanyang Technological University (NTU)

Inaugurated in 1991, Nanyang Technological University (NTU) has grown to become a full-fledged research university, and is ranked as one of the fastest-rising Asian universities in the world’s top 50**. Hailing from more than 70 countries, NTU’s 3,800 strong teaching and research staff contribute their dynamic perspectives and years of solid industry experience.

NTU’s academic and research programmes, with real-world relevance, have reaped dividends in the form of strong support from major corporations and industry leaders, in terms of both research funding and partnerships as well as global internship opportunities for our students.

As the main Science and Technology university in Singapore, NTU has made substantial contributions to Singapore’s drive for research and innovation, with the 2014 Quacquarelli Symonds (QS) ranking NTU at 10th in the World for Electrical & Electronic Engineering.

**As rated by Academic Ranking of World Universities (Shanghai Ranking) 2013, 2017/2018 and QS World University Ranking 2013/2014
TUM Asia’s Master of Science in Green Electronics (MSc in GE) equips students with the comprehensive and in-depth knowledge of micro-/nano-fabrication technology, renewable energy, power semiconductors as well as organic semiconductor devices and systems.

**COURSE OUTLINE**

- **14 Modules to be completed**
  - (2 Compulsory Lab Modules, 6 Core Technical Electives, 4 Specialization Technical Electives, 2 Non-Technical Electives)

- **45 Contact hours for most of the Core and Specialization Elective Modules**

- **2 Compulsory Laboratory Modules to be completed by every student**

**JOINT DEGREE**

Conferred by Technical University of Munich (Germany) and Nanyang Technological University (Singapore)

**APPLICATION-FOCUSED**

Full-time research and application focused programme, inclusive of 3-month internship experience and 6-month Master Thesis writing

**INDUSTRY RELEVANCE**

Our professors are actively involved in research and cooperation projects with leading industrial companies, allowing them to base the curriculum around the latest technological trends and knowledge

**GLOBAL OPPORTUNITIES**

You are able to complete your Internship and Thesis in Singapore or anywhere in the world with a company, university or research institute and look for job opportunities globally

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**Programme Timeline Overview**

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<th>July</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Graduation</th>
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| Arrival in Singapore | • Laboratory Modules  
  • Core Technical Elective Modules  
  • Specialization Technical Elective Modules  
  • Non-Technical Elective Modules | • Non-Technical Elective Modules  
  • Internship  
  • Master Thesis at a company, university or research institute (Supervised by a NTU or TUM professor) | End of Programme |

Note: This outline is a general reference to the duration of study. A student’s actual duration of study may or may not follow this general reference. This outline is subject to change during the course timetable.
Module Synopsis

Compulsory Laboratory Modules

Laboratory Module: Photonics and Device Simulation

- Device simulation: Simulate the DC characteristics of the “fabricated” device and analyze device operation with respect to potential, field, and carrier distributions as well as terminal I–V characteristics. Wafer-splint experiment. Device-target vs. process-variable relations. Transistor performance optimization/trade-offs through process variation. Technology development and optimization. Design of Experiment (DOE): Implement a computer experiment to study the scaling characteristics (varying gate length) of the given sub-micron technology. Study the influence of process variations on device performance parameters.

Laboratory 2: Design and Modeling of Nanodevices


Core Technical Elective Modules (Choose minimum 6 out of 7)

Microfabrication Technology

Materials for Electronic Devices

Bioelectronics

Nanotechnology for Energy Systems
- Approaches to nanotechnology: bottom-up vs. top-down. Characterization and fabrication issues in the nanoscale. Applications of nanotechnology in electronics, optoelectronics, telecommunications, medicine, biology, mechanics and robotics. Overview of nanotechnology programs in USA, Japan and Europe. Nanosystems for energy applications. Examples of nanotechnology energy production, energy storage, energy harvesting, and high voltage technologies. A look into the future: electro and photocatalysis, hydrogen production and storage. Economical implications of nanotechnology in the energy field.

Optomechatronic Measurement Systems

Microstructured Devices and Systems for Green Electronics
- Basic physical effects in solid-state microstructured and micromechatronical devices and their application fields (microelectronics, microsensors, microactuators, and Microsystems). Characteristic material properties of semiconductors: Intrinsic and extrinsic electrical conductivity, mobility, charge carrier transport by drift and diffusion, carrier generation-recombination, thermal conductivity, energy domain coupling effects (thermoelectricity, piezoresistance, piezoelectricity, thermoelectricity, galvanomagnetism etc.). Basic operational principles of microdevices: pn junction, MOS field effect, unipolar and bipolar transistors, Active electronic devices, power devices, various transistor effects. Phenomenological transport theory: Onsager’s transport model, continuous field models of energy-coupled multi-domain systems, physics-based macro-modeling of microsystems. Selected sensor and actuator application examples.

Introduction to Power Systems
- Structure of the power system: generation, transportation and distribution and electricity consumption. Introduction to typical power plant types including new renewable technologies. Description of the transport, distribution and control philosophy. Introduction to the electricity demand, especially due to new electronic components. Fundamentals of electrical energy economy and electricity markets. Introduction into smart grids.

Specialization Technical Elective Modules*

(Choose minimum 3 out of 7)

Lower Power Displays and Solid-State Lighting

Nonphotovoltaics

Green Nanotechnology

Photonic Electronics

Fotonic Materials
- Optical properties of nanomaterials: band structure, forbidden gap, photoluminescence, dielectric properties, refractive index, absorption spectrum. Surface plasmon resonance, dielectric functions, nanoimaging, nano-optics, nanophotonics. Interface, surface plasmon resonance, quantum well.

Semiconductor Power Devices
- Fundamentals of semiconductor device physics: electronic band structure, intrinsic and extrinsic conductivity, mobility, carrier transport by drift and diffusion, carrier generation and recombination, Shockley-Read-Hall recombination, recombination and diffusion, Power device structures: PIN diode, Schottky diode, bipolar junction transistor, thyristor, power MOSFET, insulated gate bipolar transistor (IGBT). Robustness and destruction mechanisms of power devices: thermal breakdown, electrical breakdown, dynamic avalanche, latch-up in IGBTs, cosmic ray induced failure.

Advanced MOSFET & Novel Devices
- Historical development of mainstream MOSFETs until today: economical, technological, and physical fundamentals. Properties of long channel and short channel MOSFETs, high-field effects, scaling rules. Basics of charge carrier transport, drift-diffusion, Shockley-Read-Hall transport equation. Micro-Bloch equation. Electric field effects. Power device structures: PIN diode, Schottky diode, bipolar junction transistor, thyristor, power MOSFET, insulated gate bipolar transistor (IGBT). Robustness and destruction mechanisms of power devices: thermal breakdown, electrical breakdown, dynamic avalanche, latch-up in IGBTs, cosmic ray induced failure.

Modern Semiconductor Devices
- Bipolar transistor operation principles. Bipolar device modeling.

Non-Technical Elective Modules (Choose minimum 2 out of 7)

- Business Administration
- Industrial Marketing
- Innovation and Technology Management
- Legal and Safety Aspects in Industry
- International Intellectual Property Law
- Production Planning in Industry
- Modern Developments in Industry

*Disclaimer: Elective modules available for selection are subject to availability. Unforeseen circumstances that affect the availability of the module include an insufficient number of students taking the module and/or the unavailability of the professor. TUM Asia reserves the right to cancel or postpone the module under such circumstances.
ADMISSION CRITERIA*

- You may apply to our programme if you have completed your Bachelor Degree Programme, or if you are in your final year of Bachelor Degree studies
- Hold or currently enrolled in a Bachelor Degree (completed in at least three years, depending on factors such as the rest of your education background) in Electrical or Electronics Engineering or in a closely related discipline
- Submit one (1) notarised copy of Bachelor Degree Certificate or Enrolment Letter** (if you have not completed your Bachelor Degree) and one (1) notarised copy of Academic Transcripts or Mark Sheets**
- Submit two (2) Recommendation Letters from two (2) different Professors or Employers
- Submit one (1) Statement of Purpose that indicates the reason(s) you are interested in the programme you applied for
- Submit one (1) Curriculum Vitae / Resume
- Submit TOEFL / IELTS test score taken no more than two years ago from date of submission of online application
- Submit Akademische Prüfstelle (APS) certificate (Required for applicants who hold a degree from China, Vietnam, or Mongolia)

TO APPLY

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FEES

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<th>APPLICATION FEE</th>
<th>TUITION FEE</th>
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<td>SGD 79 is payable for each application per programme</td>
<td>A total of SGD 34,240*</td>
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* The tuition fee stated is accurate as of 1 August 2018. All fees are subject to revision due to currency fluctuations, at the discretion of TUM Asia. All fees quoted are inclusive of 7% Singapore’s Government Goods & Services Tax. Please refer to our website for fee updates.

** Documents which are not in English must be translated by a certified translator. All applicants are also required to submit an additional of three (3) notarised copies of Official or Provisional Bachelor Degree Certificate, two (2) notarised copies of full, Official Academic Transcript, and three (3) passport-sized photographs when you have accepted the offer of admissions and are being matriculated into our programme.
Entrepreneurial Thinking and Engagement
Globalization is now an inevitable force that is here to stay. At TUM Asia, our classroom reflects this diversity with an enrolment of over 28 nationalities. This means that we foster a vibrant learning environment where the student learns not only from the textbook but also through the lives of their counterparts. Classroom ideas are synthesized across the diverse economic realities and students learn to see from multiple vantage points, creating a capacity to solve problems in creative ways. The unique joint degree programme not only equips the student with technical and scientific knowledge, but with an enriched curriculum consisting of business and cultural modules.

TUMCREATE
TUM is known for its research capabilities and strength in innovation. As such, TUM Asia spearheaded the set up of TUMCREATE as a base of research in Singapore. TUMCREATE is a joint programme between Technical University of Munich (TUM) and Nanyang Technological University (NTU). The electromobility institute brings together the expertise and innovation of Germany and Singapore, to drive innovation to shape the future of sustainable mobility by tackling issues ranging from the molecules to the megacity. Graduates from the TUM Asia Master programmes have the opportunity to apply for positions at TUMCreate, especially if your interest lies in the area of transportation and mobility research.

With the increase in our population and the growth of our economy, we must be more careful about how our industrial activities and resource consumption impact the environment. Electronics is one of our most developed and pervasive technologies. In this perspective, green electronics show new ways to make electronic devices that are more attentive to the consequences of the environment.

Prof. Dr. Alessio Gagliardi
Professor, Technical University of Munich
Simulation of Nanosystems for Energy Conversion
Singapore is home to approximately 20 semiconductor assembly and test operations.

DID YOU KNOW THAT A PART OF YOUR GADGET - COMPUTER, MOBILE PHONE, TABLET OR VIDEO CONSOLE - WAS DESIGNED OR MANUFACTURED IN SINGAPORE?

Clean Technology: Singapore’s Environmental Commitment

Singapore is the leading clean energy hub in the region and the prime location for major cleantech companies. Singapore’s strengths in manufacturing sectors such as electronics, precision engineering and chemicals, connectivity with regional markets, access to skilled international talent, and extensive supplier base are beneficial to cleantech companies. Singapore aims to further develop its cleantech industry, particularly its solar energy capabilities due to rising energy demands, climate change concerns and rapid technological advances. Other important growth areas are smart grids, green buildings, and energy efficiency.

The Semiconductor / Photovoltaics Industry in Singapore

In Singapore, electronics contributes 5.2% to the country’s gross domestic product (GDP). With the economic center gradually shifting to Asia, Singapore’s geographic location, open culture and strong fundamentals in the electronics industry makes her a choice location. The semiconductor industry in Singapore has the highest growth potential and is currently the fastest growing industry sector. The Photovoltaics industry in Singapore aims to offer a comprehensive array of renewable energy and eco-friendly technologies by developing improved clean electricity capabilities through solar technology.

Graduates Employability

Graduates in Green Electronics can seek employment in research institutes, companies related to green electronics all over the world, or go for higher studies.

Graduates can play professional roles in process development, process integration, as well as characterization, and device modelling in the Semiconductor industry.

Graduates in Green Electronics have extended career opportunities, not only in the electronics manufacturing industry, but also in the photovoltaic, low power display, nano- and bio-material, sensor & communication industry.

CleanTech Park is Singapore’s 1st eco-business park. It was developed for forward looking corporations that have embraced environmental sustainability.

Three of the world’s top six outsourced semiconductor assembly and test companies are located in Singapore.

In 2014, 14 silicon IC wafer fabs, 4 compound semiconductor wafer fabs, 3 Micro-Electro-Mechanical Systems (MEMS) wafer fabs and the top 3 suppliers of hard disks are located in Singapore.

Electronics is the major industry underpinning Singapore’s economic growth, it contributes 25% of the total manufacturing value-add.

The solar sector in Asia is expected to contribute to about 30% of the global solar market by 2015, compared to just over 10% in 2010.

Singapore is well positioned within the sunbelt, receiving about 50% more radiation than temperate regions such as Japan or Germany, both major hubs for solar technology today.

The Green Electronics Master programme provides students a unique opportunity to acquire high-level training in advanced electronics, as well as to study the interaction of electronics with the environment. The distinctive combination of these capabilities will equip the students to make key contributions in the sustainable development of all kinds of electronic devices.

Professor Dr.-Ing. Dr. h.c. Alexander W. Koch
Chair of Measurement Systems and Sensor Technology, MST
Technical University of Munich (TUM)