Metrology

PhD scholarships for a natural scientist or engineer.

Metrology – the science of correct measurement – is an essential cornerstone of our industrialized society. It has an impact on essentially every aspect of our lives, and metrological progress is a key enabler for technical development. Germany's oldest and renowned technical university, TU Braunschweig, and one of the leading national metrology institutes in the world, Physikalisch-Technische Bundesanstalt, joined forces to establish an international metrological training center – **Braunschweig International Graduate School of Metrology (B-IGSM)** – to foster metrological knowledge in all areas of science and engineering. Our research fields are in particular Metrology for Society, Industrial Metrology and Fundamentals of Metrology.

The Braunschweig International Graduate School of Metrology (B-IGSM) offers a structured doctorate in cutting edge research combined with a metrological qualification programme. The graduate school supports its PhD students in acquiring key competences in metrology by offering a curriculum on metrological concepts and research as well as on structures of metrology and regulatory activities. The curriculum is supplemented by workshops, topical courses, international summer schools and other activities. B-IGSM's PhD researchers are coached and advised by scientists both of the Technical University of Braunschweig and PTB.

To **support developing and emerging countries** in the field of quality infrastructure the German Federal Ministry for Economic Cooperation and Development (BMZ) provides funding for two PhD students of its partner countries engaged in natural sciences or engineering. (see list of partner countries: www.bmz.de/en/countries_regions/index.html)

Initially, **funding** will be granted for one year. Given that it typically takes three years to complete a doctoral thesis PTB will be committed to obtain a follow-up funding. The size of the grants is comparable to grants provided by the German Academic Exchange Service (DAAD). Both scholarships will be located at TU Braunschweig. Intended start of the PhD scholarship is end of 2019.

An excellent academic record and fluent English are prerequisites; skills in the German language are welcome. The submission should include CV, transcripts of the most important documents of professional qualification and a letter of application. B-IGSM promotes the professional equality of women and men and is thus especially interested in applications from women. Disabled persons will be given priority if they have the same occupational aptitude.

Any granting of a scholarship has to be approved by the International Office of TU Braunschweig taking into account the Promotionsordnung (PhD Regulations) of the respective faculty where the scholarship will be located.

Please note that any **application** needs to be submitted via the application portal of B-IGSM: *www.igsm.tu-bs.de/application/open_positions*

Deadline for applications is **15 May 2019**.

In case of any of any questions regarding the application process, please contact Ms Krakowski (j.krakowski@tu-braunschweig.de).

Applications are invited for the following six topics:

1. Optical properties and metrological relevance of nanomaterials

Within this thesis nanomaterials and composite nanomaterials based on metal oxides, metals and organic components will be prepared and investigated. The aim is to establish a basis of their use in sensors and applications in life science within a metrological framework.

Applicants should have a master or comparable degree in physics, chemistry or material science.

Further information:

Prof. Peter Lemmens
Institute of Condensed Matter Physics
TU Braunschweig
p.lemmens@tu-braunschweig.de

2. High precision additive manufacturing

The production of objects from plastics, metal or ceramics by additive manufacturing includes fascinating features. Starting from the simple creation process of form at a computer they extend to the fast prototyping and the unprecedented possibilities of combinations of materials and forms. To extend the applications to complex sensors and electronics the precision of additive manufacturing has to be improved further. The influences on precision additive manufacturing in the micrometer rage will be investigated and new strategies for improvement will be tested.

Further information:

Prof. Meinhard Schilling
Institute of Electrical Measurement Science and Fundamental Electrical Engineering
TU Braunschweig
m.schilling@tu-braunschweig.de

3. Tailoring the dispersion properties of optical waveguides for enhanced distributed temperature and strain sensing

The monitoring of infrastructures like motorways, railway-systems, pipelines, buildings, bridges and so on is very important for developing and emerging countries. In many of these countries, especially oil and gas pipelines lead through deserts and rural areas and a fast and accurate detection of leakages might save lives. Additionally, by strain sensing in bridges, dams or buildings the mechanical structure can be controlled and defects can be detected immediately in order to prevent disasters.

Distributed optical sensors can be used for this purpose. For the distributed sensing the nonlinear effect of Raman or Brillouin scattering can be incorporated. However, distributed Brillouin sensors offer many advantages compared to Raman sensors. Brillouin sensors can have spatial resolutions in the centimetre range which is comparable to point sensors like fiber Bragg gratings. However, Brillouin sensors offer a fully continuous sensing over large distances, equivalent to many thousands of distinct point sensors and no special fiber preparation is required. Thus, for more safety and the efficient prevention of dangers related to natural threats (landslides, earthquakes, avalanches, floods, etc.) and to modern constructions (tunnels, railways, pipelines, bridges, etc.) distributed sensors are expected to have a very important economic impact in developed and developing societies. Thus, over the last few years a strong research activity on SBS sensors has been seen.

However, the sensing mechanism in Brillouin sensors depends on the frequency and lifetime of an acoustical wave, generated by the interaction between two optical waves. Its frequency is a measure for temperature and strain, whereas the phonon lifetime defines the spatial resolution. Most of the Brillouin sensors use just one of these acoustical waves for sensing. Thus, the maximum sensing length and the spatial resolution of these sensors is restricted. The aim of this project is to significantly improve distributed temperature and strain sensors by the engineering of the gain spectrum of stimulated Brillouin scattering.

Applicants should have a master degree in physics or engineering and a basic experience in photonics would be advantages.

Further information:

Prof. Thomas Schneider
Institute of High Frequency Technology
TU Braunschweig
thomas.schneider@ihf.tu-bs.de

4. Traceability of Power Loss Measurements for Multilevel Converter Modules

High voltage direct current (HVDC) converter stations are the link between AC and DC transmission systems. Voltage sourced converters (VSC) are considered as an established technology. They are capable of a black-start, have good controllability and allow flexible delivery and absorption of reactive power, which makes them stand out against classical HVDC converters and enable new system services. In recent years, the introduction of the concept of modular multilevel converters

(MMC) led to more development in the VSC technology. In addition to other improvements, the achievable VSC loss margin could be reduced below 1 %.

The converter efficiency as given in the literature is determined by simulations or analytical calculations. Traceable measurement methods are needed in order to evaluate the performance of the converter valves. However, developing of such measurement systems in the laboratory is a complex process due to the very low power dissipation of modern power converters. As the converter valves consist of semiconductor switches which are capable of high switching transients, the application of the measurement setup has to be done under terms of high frequency layout. The switching transients together with the abrupt breakdown from voltages in the kilovolt range to some volts lead to the rough research environment and the demand of a specialized measurement setup.

Further information:

Prof. Michael Kurrat
Institute for High Voltage Technology and Electrical Power Systems – elenia
TU Braunschweig
m.kurrat@tu-braunschweig.de

5. Chip based microscopes for environmental monitoring

Environmental monitoring is the key to provide data sets, which subsequently serve as a basis for environmental forecasts and finally, for political decisions. Even though, from a technical point of view, we are able to monitor many important pollutants in air and water, the analytical tools available today are mostly too large, too expensive and too complex to set up a network of necessary size or to be operated in our own, private environment.

In the past years, we have developed microscopes, which are integrated on single semiconductor chips. These chip-based, lens-less microscopes are very compact, can be operated in unfriendly environments, and are very cost efficient. The institute covers the whole research chain from the development of microLEDs based on GaN technology, towards packaging of modules and software development to adopt these chip-based microscopes to the needs of the end-user. For details see e.g. the website of our European research project ChipScope (http://www.chipscope.eu/).

These chip-based microscopes now need to be moved into application, leading to joint projects with groups from biotechnology, pharmacy, medicine, and beyond.

In the frame of this call, we are looking for persons taking over one of these projects, improving the system (electronics, software) and applying the microscope to a specific measurement task. The details of the particular nanoanalytical challenge will be discussed during the interviews, and partly depends also on the interest of the applicant. The PhD project is expected to lead to a full metrological description of the chip-based system, compare it with conventional microscopes and to analyze its capabilities and potential for future applications.

The PhD work will take place in the new environment of our Laboratory for Emerging Nanometrology LENA (https://www.tu-braunschweig.de/mib/lena), which has opened in February 2019. LENA is a joint laboratory with 2,200 sqm of office and lab space, operated with our partner PTB, the second largest national metrology institute worldwide. The group of Prof. Andreas Waag at the institute of semiconductor technology is working on GaN technology, microLED technology, and the development of compact nanoanalytical systems based on these exciting devices. The institute is collaborating with Osram Opto Semiconductors GmbH, Regensburg, the second largest LED manufacturer worldwide. A joint laboratory “epitaxy competence center ec2” (https://www.tu-braunschweig.de/iht/ec2) is devoted to the development of new GaN devices. The candidate is expected to the open to collaborations with industry partners, including startups.

Further information:

Prof. Andreas Waag
Institute of Semiconductor Technology (IHT) / Laboratory for Emerging Nanometrology (LENA)TU Braunschweig
a.waag@tu-braunschweig.de

6. Energy harvester based on semiconductor nanowire arrays

More than half of the worldwide produced energy is wasted and rejected to the environment. Semiconductor nanowire (NW) arrays are a subset of the class of nanomaterials, which can help to recover waste energy from power generation, transportation, and industrial processes. They outperform the properties of their bulk counterparts by, e. g., a drastically lower thermal conductivity, which is beneficial for the figure of merit of thermoelectric heat recovery. As further key factors for a future commercialization of NWs for energy harvesting approaches, many semiconductor (e. g, silicon, ZnO, …) offer appropriate material properties (abundance, toxicity, environmental benignity) and nanoscale manufacturing methods.

In this PhD thesis work different fabrication techniques of semiconductor NW arrays, e. g., cryogenic deep reactive ion etching (cryoDRIE), metal-assisted chemical etching (MACE), chemical bath deposition (CBD) shall be compared and investigated for the manufacturing of thermoelectric energy generators (TEG). Facilities and experience are available in the cleanroom laboratory of IHT and in collaboration with PTB, e.g., e-beam lithography (EBL), nano imprint lithography (NIL) and nano sphere lithography (NSL). They shall be used for fabricating various semiconductor NW structures under the control of cross-sectional shape, diameter, length, orientation, and surface roughness, doping concentration, elasticity, fracture limit, etc. of NWs. For this purpose, various emerging nanometrology methods can be used including scanning electron microscopy (SEM), scanning probe microscopy (SPM), and spreading resistance microscopy (SSRM), nano indentation, contact resonance spectroscopy (CRS), force-distance curves (FDC), etc. NW-based TEG devices shall be fabricated and their performance shall be investigated in the typical temperature ranges of waste energy generation.

Further information:

apl. Prof. Dr. Erwin Peiner
Institut für Halbleitertechnik
TU Braunschweig
e.peiner@tu-braunschweig.de