Technische Universität Braunschweig

PTB
Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin

# Summer School on Nanometrology 2016

supported by
HELMHOLTZ FONDS e.V.

**10 – 12 August**
Kloster Drübeck, Harz

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international graduate school of metrology
braunschweig igsm

# Participants

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| **Wünsch** | Bettina | M. Sc. | b.wuensch@tu-bs.de | TU Braunschweig |

# Nanomaterials in Consumer Products: Current Regulations and Perspectives at the European Level

**Dr. Jutta Tentschert**

| | |
|---|---|
| Present Position | Senior scientist (analytical chemist) at BfR (Federal Institute for Risk Assessment, Germany), department of product safety |

Academic Record

| | |
|---|---|
| Since 2008 | Senior scientist (analytical chemist) at BfR, department of product safety |
| 2001 – 2008 | Research & development at Pfizer Ltd., Sandwich, UK |
| 2000 – 2001 | Postdoc in EU founded project 'Training and Mobility for Young Researchers' (TMR) for trace analysis at Keele University, UK |

| | |
|---|---|
| Current Projects | Elemental mass spectrometry and biotransformation \| nanotechnology \| perfluorinated chemicals |

## Abstract

With regard to nanomaterials, cosmetics as the first category among consumer products were subjected to specific requirements in the frame of European Regulation (EC) No 1223/2009. From July 2013 onwards, nanomaterials used in cosmetics have to be characterized regarding their chemical composition, particle sizes and a wide range of additional physico-chemical properties. The toxicological profiles and foreseeable exposure conditions require evaluation for all nano-furnished new cosmetic items prior to entering the market.

Food contact materials are covered by EC Regulation No 1935/2004 of 27th of October 2004. As a specific measure positive lists of substances which are intended to come into contact with food are already well established under EC regulation 10/2011. With this regulation specific information regarding nano-sized components in food contact materials is requested for the first time. The risk assessment is performed by the authorities on a case by case basis.

At the same time there is a great need for reliable information on the presence and the kinds of application of nanomaterials in consumer products to allow for a proper assessment of potential health risks. Although stipulated by many regulatory bodies throughout Europe, the demand to estimate health risks reveals still largely unmet.

Overcoming this hurdle different bodies created various databases and repositories including items labeled with the term 'nano' for product characterization, suggesting that these commodities contain nanomaterials or are enabled with nanotechnology. As most of the existing repositories are unsolicited, the given databases reveal inhomogeneous and uncertain. Sometimes the 'nano' claim is used for marketing reasons only. On the other hand, the total number of items in which nanomaterials are present, but which remain unclaimed on the package is unknown.

To gain a more profound knowledge on the real exposure levels of consumers against nanomaterials, suitable sensitive, robust and validated analytical techniques are needed to determine their presence and release specifically and correctly. In this regard, nanomaterials should be characterized and quantified in their matrix, for example in foodstuffs or cosmetics, or in spray aerosols upon release. In light of the limited number of products investigated so far, the interpretations and conclusions presented can only be considered preliminary toward the reach of the final goal of enabling toxicologically sound and in depth exposure assessments of nanomaterials.

# Dimensional Metrology at the Nanometer Level

**Dr. Jens Flügge**

| | |
|---|---|
| Present Position | Head of the department "Dimensional Nanometrology", PTB |

Academic Record

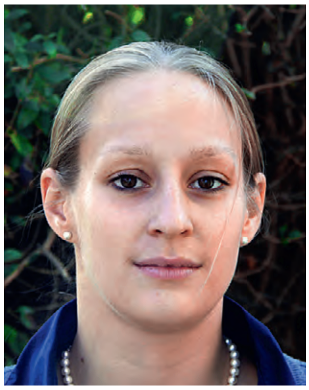
| | |
|---|---|
| since 2010 | Head of the department "Dimensional Nanometrology", PTB |
| 2000 – 2010 | Head of the PTB project "Nanometer Comparator" |
| 1996 – 2000 | Scientist at the PTB division of Precision Engineering |
| 1996 | PhD at the WZL of the RWTH Aachen (Prof. Pfeifer) |
| 1994 – 1996 | Employee at the Dr. Johannes Heidenhain GmbH |
| 1989 – 1994 | Scientist at the PTB division of Precision Engineering |
| 1983 – 1988 | Study of electrical engineering at the TU Braunschweig |

**Abstract**

Tools for high precision measurements of nanostructures and their distance depend upon precise positioning, high resolution length measurement and microscopy.

Common systems for high resolution length metrology at the nanometer level include interferometers, interferometric encoders and capacitive sensors. Besides optical microscopes, scanning probe and electron beam microscopes are key instruments. Due to the complex probe-sample interaction in these high resolution microscopes, modelling of the imaging process is necessary for the correct interpretation of the images to determine the geometry of the nano structures.

## Metrology for Nanoparticles



**Dipl.-Ing. Sabrina Zellmer**

| | |
|---|---|
| Present Position | Research Associate at the Institute for Particle Technology (iPAT), TU Braunschweig |

Academic Record

| | |
|---|---|
| Since 2011 | Research Associate at the iPAT – Branch: Nanomaterials |
| 2011 | Diploma Thesis “Optimierung des Nachweisverfahrens für Kokain in Speichelproben hinsichtlich der Kreuzreaktivität auf Benzoylecgonin” Drägerwerk AG, Lübeck |
| 2006 – 2011 | Studies of Bioengineering at TU Braunschweig |

### Abstract

The reliable characterization of the physical, chemical and toxicological properties of nanoparticles in colloidal systems is one important measurement challenge in nanoscience. Standard analytical methods offer the measurement of characteristic values of the particle size, charge, and other important parameters. In this case, a large number of nanoparticles is averaged, possessing a more or less wide distribution of properties. For statistic measurements such as particle size distribution, integral analytical methods are sufficient – but for the determination of specific or distinct properties of the particles, such as the ellipticity, the number of functional groups per particle as well as the number of a small particle fraction in a broadly distributed particle system, complementary methods are necessary. Using counting methods, individual properties can be detected, but the detailed characterization of these nanomaterials is limited. Only high resolution microscopy techniques, such as TEM or AFM, are suitable to obtain accurate structural information for individual particles and particle structures – but the preparation of the samples influences the results of these measurements, and typically only a small fraction of the sample can be analyzed. Hence, only via a wise combination of different analytical approaches reliable information on a system is generated.

In our group, a specific liquid phase based method, the non-aqueous synthesis is used and studied in detail to synthesize well-defined nanoparticulate structures with narrow size distributions, controlled nanoparticle sizes and morphologies as well as defined crystal structures. For the characterization of the ensemble properties as well as of the individual nanoparticle properties for example the SAXS technique (SAXS, ASAXS, USAXS and GISAXS) is combined with microscopy techniques. Furthermore, to determine individual surface properties (surface metrology), such as the number of functional groups per nanoparticle, the coordination of ligands on the surface and the binding energies between different ligands and nanoparticles, NMR spectroscopy (DOSY, NOESY and COSY), isothermal titration calorimetry (ITC) and two-photon-fluorescence microscopy were combined in our group. Using these complementary approaches, the thorough characterization of nanoparticles during their growth process, as well as during subsequent modification, functionalization and post-processing have been established. As an example, hierarchical and self-assembled particle-based structures that can be widely adjusted in their structural properties are presented.

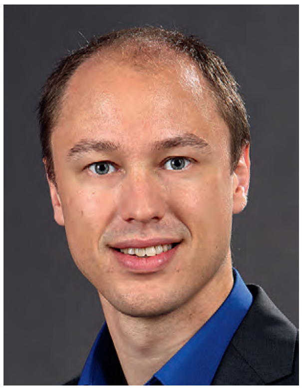
# Scanning Force Microscopy (SFM) Methods – What Can Go Wrong?

**Prof. Dr. Heinz Sturm**

| | |
|---|---|
| Present Position | Head of the division "Nanotribology and Nanostructuring of Surfaces", BAM – Federal Institute for Materials Research and Testing, Berlin |
| Academic Record | |
| since 1990 | BAM – Federal Institute for Materials Research and Testing, Berlin |
| 1990 | PhD focused on Physical Chemistry from TU Clausthal |
| 1977 – 1984 | Studies of Chemistry, Universität Kaiserslautern |
| Scientific Interests | Research topics include initiation of energetic materials on the nanoscale, imaging procedures for vibrating structures and systems (DySEM), dynamic-mechanical SFM methods at nanocontacts as well as piezoelectric and electrostrictive effects of polymers, zero friction, nanocomposites, confocal raman imaging, low energy electrons and electrospinning. |

## Abstract

Metrology is the science of measurement. We still forget far too often that measurements contain uncertainties at any level, especially at the nanoscale. The simple fact that SFM (or Atomic Force Microscopy – AFM) enables us to "see" atoms does not mean that simultaneously recorded heights (topography) or physical properties such as stiffness or electric conductivity are performed with high precision. Here we still have to accept that there is no standard procedure to ensure that measurements are absolutely certain. Moreover, users often feel left alone by manufacturers and vendors who focus solely on the measurement of signals instead of also explain the physical meaning including the necessary theory. This contribution starts with an introduction to SFM measurement techniques, highlights the strengths and weaknesses of the techniques and demonstrates some physical limits. A presentation of some complex examples with obvious uncertainties follow.s Some major questions remain and are focused at the end of this contribution to inspire the following discussions.



# Time-resolved Photoelectron Spectroscopy: An Ultrafast Clock to Study Electron Dynamics in Molecular Hybrid Systems

**Jun.-Prof. Dr. Benjamin Stadtmüller**

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| Present Position | Junior Professor (W1) in Experimental Physics, University of Kaiserslautern |

Academic Record

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|---|---|
| 2015 – | Junior Professor (W1) in Experimental Physics, University of Kaiserslautern |
| 2014 – 2015 | Postdoc, University of Kaiserslautern (AG Prof. M. Aeschlimann) |
| 2012 – 2013 | Postdoc, Research Center Jülich (AG Prof. C. Kumpf) |
| 2009 – 2012 | Ph.D. Fellow, Research Center Jülich (AG Prof. C. Kumpf) |
| 2005 – 2009 | Studies of Physics, University of Würzburg, Germany |

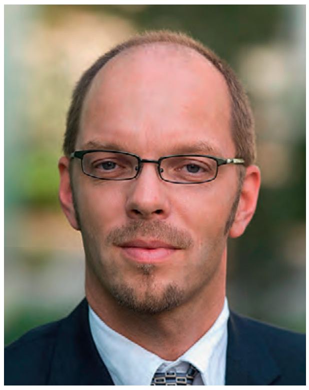
**Abstract**

Excited electrons play a crucial role for many fundamental chemical and physical phenomena occurring at surfaces, (hybrid) interfaces, or in bulk materials. For instance, they determine the properties of photo-induced catalysis at surfaces or the efficiency of charge transport across interfaces between different materials. The latter is of particular interest as transport properties of electrons through interfaces are responsible for the performance of new nanoscale molecular electronic devices.

To gain insight into the fundamental mechanisms that govern the dynamics of excited charge and spin carriers, their excitation and dissipation channels have to be investigated in real time. This is rather challenging since they occur on a femtosecond timescale. Only recently, this timescale became experimentally accessible by the realization of ultrashort laser pulses with durations of only a few femtoseconds ($10^{-15}$ s). These laser pulses can then be employed in pump-probe experiments in which a first light pulse excites charge and spin carriers in the material while a second light pulse at a well-defined time delay probes the evolution of the excited electrons on ultrafast timescales.

In this presentation, I will demonstrate the potential of this time-resolved approach to study the ultrafast electron dynamics in metal-organic hybrid systems. The fs-dynamics is monitored by angle resolved photoelectron spectroscopy, i.e., by recording the energy and momentum distribution of photoelectrons that are created by the probe pulse. For prototypical hybrid systems such as PTCDA or $C_{60}$ adsorbed on metallic hetero-systems, we investigate the momentum-resolved dissipation channels of excited electrons. Distinct differences between various material systems allow us to reveal the role of the molecule-substrate interaction on the electron dynamics in these systems. Furthermore, we will show that the fs dynamics in these material systems also depend crucially on the optical excitation strength. These exemplary results demonstrate that time-resolved photoemission can be used as an ultrafast clock to study electron dynamics in metal-organic hybrid systems.

# Squeezed States of Light and their Applications in Laser Interferometers



**Prof. Dr. Roman Schnabel**

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| Present Position | Full Professor (W3) at Universität Hamburg,<br>Institut für Laserphysik & Zentrum für Optische Quantentechnologien |

## Academic Record

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| since 2014 | Full Professor (W3) at Universität Hamburg |
| 2008 – 2014 | Full Professor (W2) at Leibniz Universität Hannover |
| 2003 – 2008 | Juniorprofessor at Leibniz Universität Hannover |
| 2002 – 2003 | Research fellow at the Max Planck Institute for Gravitational Physics |
| 2000 – 2002 | Research fellowship of the Alexander von Humboldt Foundation<br>at the Australian National University, Canberra |
| 2000 | Research fellow at the Max Planck Institute for Quantum Optics, Garching |
| 1994 – 1999 | Studies of Physics, Universität Hannover |

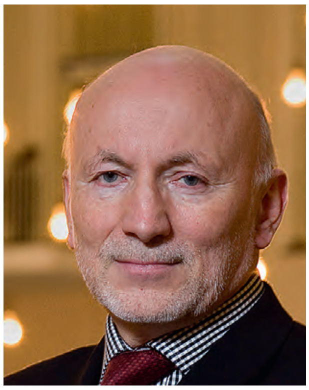
## Awards

| | |
|---|---|
| 2000 | Feodor Lynen Fellowship of the Alexander von Humboldt Foundation |
| 2012 | The 2013 Joseph F. Keithley Award of the American Physical Society |


## Abstract

Measurement sensitivities are fundamentally limited by quantization noise, or just quantum noise in short. Furthermore, Heisenberg's Uncertainty Principle demands measurement back-action for some observables of a system if they are measured repeatedly. In this respect, squeezed states are of high interest since they show a 'squeezed' uncertainty, which can be used to improve the sensitivity of measurement devices beyond the usual quantum noise limits including those impacted by quantum back-action noise. Squeezed states of light can be produced with nonlinear optics, and a large variety of proof-of-principle experiments were performed in past decades. As an actual application, squeezed light has now been used for several years to improve the measurement sensitivity of GEO 600, which is a laser interferometer built for the detection of gravitational waves. Given this success squeezed light is likely to significantly contribute towards the realization of gravitational wave astronomy. This talk presents the concept of squeezed states, with a focus on experimental observations. The role of the light's quantum noise in laser interferometers is summarized and the first true application of squeezed states in these measurement devices is reviewed.

# Quantum Systems in µ-g and on Earth – New Horizons for Quantum Sensors



**Prof. Dr. Wolfgang Ertmer**

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| Present Position | Professor (C4) at the Institute of Quantum Optics, Leibniz University Hannover |

## Academic Record

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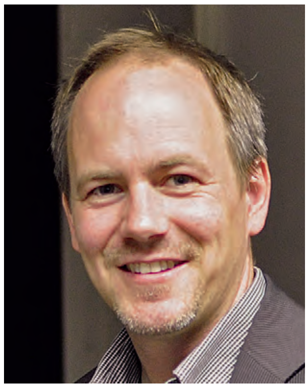
| since 1994 | Professor (C4) at the Institute of Quantum Optics, Leibniz University Hannover<br>Managing Director of the Institute of Quantum Optics, several times since 1994 |
| 1985 – 1994 | Professor (C2/C3) at the Rheinische Friedrich-Wilhelms-Universität Bonn |
| 1985 | Habilitation in Physics, Rheinische Friedrich-Wilhelms-Universität Bonn |
| 1984 | Visiting Scientist at the Joint Institute for Laboratory Astrophysics,<br>Boulder, Colorado, USA (collaborating with John L. Hall) |
| 1982 – 1983 | Research fellowship of the DFG at the Joint Institute for Laboratory Astrophysics,<br>Boulder, Colorado, USA (collaborating with John L. Hall) |
| 1978 – 1982 | Research fellow at the Rheinische Friedrich-Wilhelms-Universität Bonn |
| 1978 | PhD Thesis in Physics, Rheinische Friedrich-Wilhelms-Universität Bonn,<br>supervisor: Siegfried Penselin |
| 1975 – 1978 | Scientific assistant at the Rheinische Friedrich-Wilhelms-Universität Bonn |
| 1970 – 1975 | Study of Physics, Rheinische Friedrich-Wilhelms-Universität Bonn |

## Abstract

In the recent past we have witnessed many breakthroughs in quantum science and new developments for innovative quantum technologies. Quantum engineering of light and matterwave fields based on ultracold atoms was one of the main drivers for this fast progress. For example, inertial sensing based on atom interferometry surpassed in the meantime the sensitivity, stability, and accuracy of classical sensors. Another example is the stability and accuracy of optical atomic clocks, approaching uncertainties in the $10^{-18}$ domains. The technologic readiness of such apparatus has reached a level that very complex experiments can be designed for missions in micro-g, e.g., in the drop-tower in Bremen, or in space on the ISS, or on free flying satellites. This opens new perspectives for Earth observation and tests of fundamental physical laws. During the talk I will provide an insight into these developments and present typical examples for applications like, e.g., relativistic geodesy.

# Biosensing, Principles and Developments



**Prof. Dr. Philip Tinnefeld**

| | |
|---|---|
| Present Position | Professor of Biophysical Chemistry,<br>Institut für Physikalische und Theoretische Chemie, TU Braunschweig |

Academic Record

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|---|---|
| since 2010 | Full Professor (W3) of Biophysical Chemistry, TU Braunschweig |
| 2009 | Academy Prize for Chemistry of the "Akademie der Wissenschaften zu Göttingen" |
| 2007 – 2010 | Associate Professor (W2) of Biophysics, Ludwig-Maximilians-Universität, München |
| 2007 | Visiting Professor of Biophysics, Ludwig-Maximilians-Universität, München |
| 2003 – 2007 | Assistant Professor (C1), Physics Faculty, Applied Laser Physics & Spectroscopy, Universität Bielefeld (Department Prof. M. Sauer) |
| 2006 | Habilitation, venia legendi for Physics |
| 2002 – 2003 | Postdoc in the groups of Shimon Weiss (UCLA), Markus Sauer (Heidelberg) and Frans C. DeSchryver (Leuven) |
| 2001 | Schloessmann Award of the Max-Planck-Society |
| 1999 – 2002 | PhD, Physical Chemistry, Universität Heidelberg, supervised by Prof. Dr. J. Wolfrum |
| 1998 | M. Sc., Physical Chemistry, Universität Heidelberg |

| | |
|---|---|
| Scientific Interests | Single-molecule fluorescence spectroscopy \| super-resolution microscopy \| DNA nanotechnology |

## Abstract

Sensing molecules in dilute solution is a grand challenge of modern environmental monitoring, homeland security and molecular diagnostics. Commonly, selectivity is provided by a molecular recognition event with the target molecule. Here, the diffusion problem of finding the molecule has to be overcome. In the next step, reporting by an intelligent transduction mechanism is required which can, e.g., be electrical, optical or mechanical. Recent developments will be highlighted that have a special focus on miniaturization and low-tec point-of-need instrumentation.

# Fast Detection of Trace Compounds in Liquids and Air by Ion Mobility Spectrometry

**Prof. Dr.-Ing. Stefan Zimmermann**

| | |
|---|---|
| Present Position | Professor for sensors and measurement technology, Leibniz Universität Hannover |
| Academic Record | |
| since 2009 | Full Professor (W3) for sensors and measurement technology, Leibniz Universität Hannover |
| 2004 – 2009 | Head of Chemical and Biochemical Sensors (latest position), Drägerwerk AG & Co. KGaA, Lübeck |
| 2001 – 2004 | Postdoctoral scientist at the Berkeley Sensor and Actuator Center, University of California, Berkeley, USA, Feodor Lynen Fellowship of the Alexander von Humboldt Foundation |
| 2001 | Doctoral thesis (Dr.-Ing.), Technical University Hamburg-Harburg |
| 1996 – 2001 | Research engineer, Institute of Microsystems Technology, Technical University Hamburg-Harburg |
| 1996 | Diploma in electrical engineering, Technical University Hamburg-Harburg |
| Scientific Interests | Development of sensors and nanosensors for ultra-sensitive trace compound detection |


## Abstract

Ion mobility spectrometers (IMS) are compact devices for very fast and sensitive trace compound detection in liquids and air for various safety and security related applications (e.g., drugs, toxic compounds and explosives). Nowadays, IMS are increasingly used in different other applications, such as life sciences (breath metabolite screening, bacteria identification, water quality monitoring). The high sensitivity of IMS for certain substances with detection limits in the pptv-range is based on analyte ionization by chemical gas phase reactions. After ionization the analyte ions will be separated by their ion mobility in an electrical drift field. Since IMS operate at about 1000 mbar no vacuum system is required which significantly reduces instrumental effort compared to mass spectrometers. For personal air monitoring even hand-held IMS are available. However, limited spectral resolving power and chemical cross sensitivities are major disadvantages of IMS. The presentation will give a comprehensive overview of ion mobility spectrometry covering fundamentals, ionization sources, compact IMS with ultra-high resolving power, hyphenated and miniaturized systems as well as new approaches to overcome the chemical cross sensitivities.

# Towards Calibrated Nanoscale Photodetectors

**Prof. Dr. rer. nat. Tobias Voß**

| | |
|---|---|
| Present Position | Professor (W2) at the Institut für Halbleitertechnik, TU Braunschweig |

Academic Record

| | |
|---|---|
| since 2014 | Professor (W2) at the Institut für Halbleitertechnik, TU Braunschweig |
| 2012 – 2013 | Business Development Manager, Fraunhofer Heinrich-Hertz-Institute, Fiber-Optical Sensor Systems, Goslar |
| 2011 – 2012 | Substitute Professorship "Nanotechnology", IMTEK Institute for Microsystems Engineering, University of Freiburg |
| 2008 | Habilitation in Experimental Physics, University of Bremen |
| 2006 – 2007 | Visiting Scientist, Harvard University, Cambridge MA (USA) |
| 2004 – 2014 | Research Scientist at the Institute of Solid State Physics, University of Bremen |
| 2004 | PhD in Experimental Physics (Dr. rer. nat), University of Bremen |
| 2001 | Diploma in Physics, Clausthal University of Technology |
| 1999 | Visiting Scholar, University of Colorado at Boulder, Boulder CO (USA) |

| | |
|---|---|
| Scientific Interests | Nanowire Optoelectronics and Nanowire Sensors \| Hybrid Nanostructures for optoelectronics and sensing, CVD of conductive polymers \| Femtosecond Optical Hyperdoping |

## Abstract

Inorganic semiconductor nanowires with diameters of less than 100 nm and lengths of several microns constitute a versatile class of nanostructures that has already proven to be powerful for developing nano-LEDs, nano-lasers, nano-FETs, nano-solar cells, and a variety of different nano-sensors. One particularly interesting application of semiconductor nanowires is the design of novel nanoscale photodetectors. In a photodetector, the absorption of an incident photon typically promotes an electron from the valence band to the conduction band and thus creates a transient change of the electronic properties. Through an appropriate design of the device (nanowire material, dimensions, doping profile, electrical contacts, external circuit elements), an electrical signal proportional to the number of absorbed photons can be generated for a certain range of photon fluxes. Calibrated nanowire photodetectors will allow us to quantitatively measure the spatial intensity distribution of a light beam with a resolution of 100 nm or even below.
The application of nanowire photodetectors requires a traceable calibration of the device. This talk will discuss the basic properties of the light field and the semiconductor nanowire, and discuss the steps which are required to achieve a traceable calibration of the nanowire photodetector's response.

| Last Name | First Name | Title of Poster |
|---|---|---|
| Balceris | Christoph | **Uncertainty of dynamic magnetic measurements** |
| Bezshlyakh | Daria | **Complete Blood Test on a smart phone basis** |
| Gabay | Kim-Leigh | **Measurement of 3D dose rate distributions in brachytherapy** |
| Greeff | Gabriel Pieter | **3D printing filament velocity measurement influence factors and considerations** |
| Guo | Xiaofei | **Electrical measurements on the human body** |
| Hamdana | Gerry | **Optimized colloidal lithography for manufacturing of sub-100 nm silicon nanowires** |
| Hampel | Benedikt | **Measurement uncertainties of terahertz microscope measurements with Josephson cantilevers** |
| Hashemi | Payam | **Multi-block copolymers of glucan ethers** |
| Hassan | Saher | **Dynamic force transfer standard for dynamic applications: Error analysis** |
| Hein | Christopher | **Structural properties of GaN quantum dots investigated using a combination of different characterization techniques** |
| Jantzen | Stephan | **Handling and cleaning of micro-parts** |
| Jusuk | Ija | **Photophysics und Super Resolution Fluorescence Microscopy using DNA-Nanodevices** |
| Ketzer | Fedor Alexej | **Determination of the internal quantum efficiency of GaInN quantum well structures** |
| Kruskopf | Mattias | **Synthesis of bilayer-free graphene for quantum resistance metrology** |
| Liu | Bo | **Detection of Molecules with low concentration by using SERS** |
| Molle | Julia | **Studying the influencing effects on length measurement with DNA Origami** |
| Nazari Asl | Sara | **Noise Characteristics of Capacitive Electrodes** |
| Nording | Felix | **Measurement uncertainty of magnetic noise of XMR-sensors** |
| Ostermann | Johannes | **Implementation of a metrological UHV-STM** |
| Raab | Mario | **Shifted single molecule fluorescence by plasmonic coupling: a nanoscale mirage** |
| Rodiek | Beatrice | **Realisation of an absolute single-photon source** |
| Rojas Hurtado | Carol Bibiana | **Design of a nanophotonic analyzer for on-chip QKD** |
| Schmidt | Sarah | **Complex Measurands in Biological Systems : Raman Spectrometry** |
| Schneider | Philipp | **Detector development and related measurement uncertainty components** |
| Schroeter | David | **Fabrication of MnSi Nanostructures** |
| Setiadi | Rahmondia Nanda | **Fluxgate Magnetic Sensor Properties** |
| Steinki | Nico | **Resistivity of MnSi nanostructures** |
| Struszewski | Paul | **Characterization of high-speed photodetectors: statistic and systematic errors** |
| Su | Ying | **Measurement standard for compliance test systems** |
| Sumin | Dmytro | **Evaluation of geometrical parameters of workpieces in serial production under harsh environmental conditions by referring to calibrated reference** |
| Weber | Martin | **Influencing effects on the calibration of hydrophones** |
| Weidinger | Paula | **Influences on the Torque Transfer Standard for nacelle test bench calibration** |
| Werian | Anne | **The uncertainty of mercury isotopic measurements** |
| Won Dias Victorette | Milena | **Investigation of flat screen monitors for the generation of reference patterns in optical metrology** |
| Wünsch | Bettina | **Estimating the influencing effects on DNA origami nanolenses** |

# Timetable

## Wednesday 10th August

- **14:00** – **Welcome**
- **14:30** – Jutta Tentschert: **Nanomaterials in Consumer Products: Current Regulations and Perspectives …**
- **15:30** – Coffee Break
- **16:00** – Jens Flügge: **Dimensional Metrology at the Nanometer Level**
- **17:00** – Sabrina Zellmer: **Metrology for Nanoparticles**
- **18:00** – Dinner
- **19:30** – **Get Together | Poster Setup**
- **20:30**

## Thursday 11th August

- **08:30** – Heinz Sturm: **Scanning Force Microscopy (SFM) Methods – What Can Go Wrong?**
- **09:30** – Benjamin Stadtmüller: **Time-resolved Photoelectron Spectroscopy: An Ultrafast Clock …**
- **10:30** – Coffee Break
- **11:00** – Roman Schnabel: **Squeezed States of Light and their Applications in Laser Interferometers**
- **12:00** – Lunch
- **13:30** – Walk Break
- **14:30** – Wolfgang Ertmer: **Quantum Systems in µ-g and on Earth – New Horizons for Quantum Sensors**
- **15:30** – Coffee Break
- **16:00** – **Exercise**
- **18:00** – Dinner
- **19:30** – **Poster Session**
- **20:30**

## Friday 12th August

- **08:30** – Philip Tinnefeld: **Biosensing, Principles and Developments**
- **09:30** – Stefan Zimmermann: **Fast Detection of Trace Compounds in Liquids and Air by Ion Mobility Spectrometry**
- **10:30** – Coffee Break
- **11:00** – Tobias Voß: **Towards Calibrated Nanoscale Photodetectors**
- **12:00** – Lunch
- **13:30**