Vacuum Science and Technology Division
Fachverband Vakuumphysik und Vakuumtechnik (VA)

Thomas Giegerich
Karlsruhe Institute of Technology (KIT)
Institute for Technical Physics
Hermann-von-Helmholtz-Platz 1
76344 Eggenstein-Leopoldshafen, Germany
thomas.giegerich@kit.edu

Overview of Invited Talks and Sessions

(Lecture halls H2 and H6)

Invited Talks

VA 2.1	Mon	9:30–10:10	H6	**Vacuum metrology and its impact on research and industry** — •Karl Jousten, Matthias Bernien
VA 4.1	Mon	14:00–14:40	H6	**Development of a new wireless SAW-Pirani vacuum sensor with extended range and sensitivity** — •Sofia Toto, Juergen Brandner
VA 5.1	Mon	15:25–16:05	H6	**Outgassing rate measurements in practice: feasibility and comparability** — •Michael Flämmich, Francisc Haidu, Christian Worsch, Marcel Klessen, Klaus Bergner, Ute Bergner

Invited talks of the joint Symposium SKM Dissertation-Prize 2019

See SYSD for the full program of the symposium.

SYSD 1.1	Mon	9:30– 9:50	H2	**Synchronization and Waves in Confined Complex Active Media** — •Jan Frederik Totz
SYSD 1.2	Mon	9:50–10:10	H2	**Spin scattering of topologically protected electrons at defects** — •Philipp Rüssmann
SYSD 1.3	Mon	10:10–10:30	H2	**Beyond the molecular movie: Revealing the microscopic processes behind photo-induced phase transitions** — •Chris W. Nicholson
SYSD 1.4	Mon	10:30–10:50	H2	**Thermodynamic bounds on current fluctuations** — •Patrick Pietzonka
SYSD 1.5	Mon	10:50–11:10	H2	**Lightwave-driven quasiparticle acceleration** — •Fabian Langer
SYSD 1.6	Mon	11:10–11:30	H2	**Ultrafast plasmon-driven point-projection electron microscopy** — •Jan Vogelsang
SYSD 1.7	Mon	11:30–11:50	H2	**Helimagnets, sand patterns and fingerprints linked by topology** — •Peggy Schönherr

Invited talks of the joint Symposium Czech Republic as Guest of Honor

See SYCZ for the full program of the symposium.

SYCZ 1.1	Thu	9:30–10:00	H4	**Crystal symmetries and transport phenomena in antiferromagnets** — •Tomas Jungwirth
SYCZ 1.2	Thu	10:00–10:30	H4	**Terahertz subcycle charge and spin control** — •Rupert Huber
SYCZ 1.3	Thu	10:30–11:00	H4	**1D molecular system on surfaces** — •Pavel Jelinek
SYCZ 1.4	Thu	11:15–11:45	H4	**Tunneling microscopy on insulators provides access to out-of-equilibrium charge states** — •Jascha Repp
SYCZ 1.5	Thu	11:45–12:15	H4	**Occam's razor and complex networks from brain to climate** — •Jaroslav Hlinka
SYCZ 1.6	Thu	12:15–12:45	H4	**Long range temporal correlations in complex systems** — •Holger Kantz

Sessions

VA 1.1–1.4	Sun	16:00–18:20	H2	**Next generation of SI-Units (joint session VA/TT/TUT)**
VA 2.1–2.5	Mon	9:30–12:15	H6	**Vacuum Metrology**
VA 3.1–3.1	Mon	12:30–13:00	H32	**Gaede Prize Talk: Selina Olthoff (joint session PRV/DS/VA)**
VA 4.1–4.2	Mon	14:00–15:25	H6	**New Vacuum Gauges - Development and Characterization**
VA 5.1–5.3	Mon	15:25–17:05	H6	**Vacuum Measurement in Technical Applications**
VA 6	Mon	17:15–18:00	H6	**Annual General Meeting of the Vacuum Science and Technology Division**

Annual General Meeting of the Vacuum Science and Technology Division

Monday 17:15–18:00 H6

- Bericht
- Verschiedenes

VA 1: Next generation of SI-Units (joint session VA/TT/TUT)

Time: Sunday 16:00–18:20 Location: H2

Tutorial VA 1.1 Sun 16:00 H2

A Quantum-Based Pressure Standard for a New SI Realization of the Pascal — •Jay Hendricks — NIST Thermodynamic Metrology Group, Gaithersburg, MD, US

Moving forward, the next generation of pressure standards will provide a new route of SI traceability for the pascal. By taking advantage of both the properties of light interacting with a gas and that the pressure dependent refractive index of helium can be precisely predicted from fundamental, first-principles quantum-chemistry calculations, a new route of realizing the pascal has been demonstrated. This lecture will briefly cover the classical methods of realizing pressure that have served the metrology community well for the past 375 years. And then will take a deeper dive into the next generation of light-based pressure standards that will enable the elimination of mercury manometers, replacing them with a smaller, lighter, faster, and higher precision standards. From a metrology stand point, the new quantum-based SI pascal will move us from the classical force/area definition, to an energy density (joules per unit volume) definition. Should the technique be further miniaturized, it will lead to a revolution in pressure metrology, enabling a photonics based device that serves both a gas pressure sensor and a portable gas pressure standard all in one.

Tutorial VA 1.2 Sun 16:35 H2

Redefinition of the Kelvin - With what accuracy can temperatures be measured? — •Steffen Rudtsch — Physikalisch-Technische Bundesanstalt (PTB), Abbstraße 2-12, 10587 Berlin

On 20 May 2019, World Metrology Day, the revised International System of Units (SI) will enter into force. From this day on, all units will be traced back to natural constants. The redefinition of the Kelvin via the Boltzmann constant opens up new possibilities in the field of high-precision temperature measurements and metrological traceability. The lecture gives an overview of the currently used precision measurement methods in contact thermometry, in the range from 1 mK to 2000 °C, and shows which changes result from the new definitions.

Tutorial VA 1.3 Sun 17:10 H2

The new kilogram - Now approachable for extraterrestrials and nonhumans — •Frank Härting — Physikalisch-Technische Bundesanstalt (PTB), Abbstraße 2-12, 10587 Berlin

The presentation gives an overview of the work that have been done and which is still in progress in order to realize the new kilogram after the redefinition of the SI on Mach 20, 2019. Beside some historical information, the presentations will focus on the actual and future scientific challenges that have to be solved in mass metrology.

Tutorial VA 1.4 Sun 17:45 H2

Counting electrons for the new ampere — •Frank Hohls — Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, 38116 Braunschweig, Germany

On November 16th 2018 the General Conference for Weights and Measures, CGPM, adopted the resolution on the biggest revision of the International System of Units (SI) in its history: From May 20th on the SI system is completely determined by fixing the values of 7 constants of nature. One of these constants is the elementary charge which will have the exact value e = 1.602 176 634 * 10-19 As. For the unit of electrical current, the Ampere, this has the nice consequence, that the physics of electrical current and the definition of the ampere are rejoined: Counting or controlling the number of electrons passing a conductor in each second will be the natural realization of the ampere. This could be achieved by a single-electron transport (SET) pump that transfers exactly n electrons in each of its operation cycles, generating a quantized current I = nef when operated at a frequency f. The present state of the art of the SET based current standard with emphasis on the most advanced candidate will be reviewed, a SET pump based on dynamic semiconductor quantum dots with electrically tunable energy barriers.

VA 2: Vacuum Metrology

Time: Monday 9:30–12:15 Location: H6

Invited Talk VA 2.1 Mon 9:30 H6

Vacuum metrology and its impact on research and industry — •Karl Jousten and Matthias Bernien — Physikalisch-Technische Bundesanstalt, Institut Berlin, Abbestr. 2-12, 10587 Berlin

Whenever a physical quantity like vacuum pressure is being measured it is important that the indication of the instrument is in agreement with the International System of Units (SI). Normally, the user does not want to take care of this, but the manufacturers of the instruments and the calibration services need to. The measurement of vacuum covers 15 decades and needs instruments that realize quite different physical effects of pressure or gas density. While the mechanical deformation of membranes or thermal conductivity are used in rough and medium vacuum, the instruments for high and ultra-high vacuum measure the impingement rate of gas molecules or their number density in some volume. Vacuum presents the necessary environment for many research activities and industrial processes, however, just a few applications need high accuracy of the vacuum measurement. Leak rate measurements or outgassing rate measurements have to ensure that components are correctly qualified for their purpose as e.g. cardia pacemakers or components in EUV lithography. In the future, it can be expected that optical methods like laser spectroscopy and refractive index measurements will play a more important role in vacuum measurement.

VA 2.2 Mon 10:10 H6

Vacuum-compatible photon-counting hybrid pixel detector for WAXS, XRD and XRR in the tender X-ray range — •Dieter Skroblin[1], Levent Cibik[1], Benjamin Lüthi[2], Swenja Schreiber[1], Maximilian Luttkus[1], Alexander Schavkan[1], Mika Pflüger[1], and Michael Krumrey[1] — [1]Physikalisch-Technische Bundesanstalt (PTB), Abbestraße 2-12, 10587 Berlin, Germany — [2]DECTRIS Ltd., Neuenhoferstrasse 107, 5400 Baden, Switzerland

A vacuum-compatible photon-counting hybrid pixel detector has been installed in the UHV reflectometer of the four-crystal monochromator beamline of the Physikalisch-Technische Bundesanstalt (PTB). The setup was developed in cooperation with Dectris Ltd. and is based on the PILATUS3 100k module. The quantum efficiency, homogeneity, angular dependence and linearity of the new detector have been investigated. First results of the performance in wide-angle X-ray scattering (WAXS), X-ray diffraction (XRD) and X-ray reflectometry (XRR) are presented.

15 min. break

VA 2.3 Mon 10:55 H6

Vacuum Pressure Measurement in Industrial Environments — •Martin Wüest — INFICON AG, Alte Landstrasse 6, LI-9496 Balzers, Liechtenstein

The theme of this session is "Metrology is the key for your success in research and industry". Indeed poor process control leads to large product tolerances, commonly associated with low product quality. However, the word "metrology" is more often associated with National Measurement Institutes (NMI) than with industrial practice. At NMI we have benign conditions with a clean environment, temperature stability, knowledgeable personnel and plenty of time for a thorough calibration. The industrial world is different. We have seasonal and daily ambient temperature swings, we have vibration, magnetic interference, harsh process chemistries and the like. Time is money; therefore high cadence process steps are favored. To bring the science of measurement to industry is a challenge. Sensors are expected to reliably and reproducibly measure process variables in a non-ideal environment. I will present cases demonstrating what we had to do to make our vacuum gauges better withstand the real industrial world.

VA 2.4 Mon 11:25 H6

Absorption spectroscopy for process monitoring of technological plasmas — •Jürgen Röpcke, Mario Hannemann, Sarah-Johanna Klose, Norbert Lang, Alexander Puth, and Jean-Pierre H. van Helden — Leibniz Institute for Plasma Science and Technology, Greifswald, Germany

Mid infrared absorption spectroscopy (AS), based on quantum cascade lasers (QCLs) has progressed considerably as a powerful diagnostic technique for in situ studies of molecular plasmas. The increasing interest in processing plasmas containing molecular precursors has led to further applications of QCLAS because most of these compounds and their decomposition products are infrared active. QCLAS provides a means of determining the absolute concentrations of the ground states of stable and transient molecular species, which is of particular importance for the investigation of reaction kinetics. Since plasmas with molecular feed gases are used in many applications such as thin film deposition, semiconductor processing, surface activation and cleaning, and materials and waste treatment, this has stimulated the adaptation of infrared spectroscopic techniques to industrial requirements. The recent availability of frequency combs as new radiation sources for MIR-LAS will open up completely new options in process monitoring.

VA 2.5 Mon 11:55 H6

Nothing without vacuum! — •Ute Bergner — Deutsche Vakuum Gesellschaft (DVG)

Vacuum technology plays an important role in the progress of major industries. The rise of many applications enabled only by the use vacuum in the 20th century lead the foundation of vacuum societies. The roots of the German Vacuum Society founded in 1963 go back to the 1950s when physicists, engineers and others founded several organizations in order to exchange experiences and knowledge in the field of vacuum technique and physics. More than ever, vacuum technology is an essential enabler of high technologies and advances many fields of research. The talk gives an insight into the aims and activities of the DVG, its collaboration and interaction with the DPG, the IUVSTA and networking opportunities with industry.

VA 3: Gaede Prize Talk: Selina Olthoff (joint session PRV/DS/VA)

Time: Monday 12:30–13:00 Location: H32

Prize Talk VA 3.1 Mon 12:30 H32

Absolute energy levels and interface energetics of halide perovskites — •Selina Olthof — Institute of Physical Chemsitry, University of Cologne, Luxemburger Strasse 116, 50939 Cologne, Germany — Laureate of the Gaede-Prize 2019

In recent years, the interest in halide perovskites rose at a rapid pace due to their tremendous success in the field of photovoltaics; but other fields, like light emitting diodes, show great potential as well. In such devices, the function and performance depend on the proper alignment of energy levels throughout the device, i.e. allowing for efficient charge transport across the various interfaces. Here, an advantage of these novel semiconductors is that the electronic structure and band gap can be readily tuned by changing the compositions of the perovskite. In this talk, I will discuss recent findings regarding the variations in electronic structure of halide perovskites measured by a combination of UV-, inverse, and x-ray photoelectron spectroscopy (PES); in this extensive study, we cover all primary lead and tin based halide systems. Combining these results with DFT calculations and a tight binding model we are able to consistently describe variations found in the electronic structure. However, not only the absolute energy levels of these materials are of interest, but also their alignment to adjacent transport layers, as interface dipoles and band bending can significantly alter the electronic landscape within a device. We also performed interface resolved PES studies on the MAPbI3 system. Comparing various bottom contacts we can show that chemical interactions, band bending, and interface dipole formation indeed play an important role in these perovskite systems.

VA 4: New Vacuum Gauges - Development and Characterization

Time: Monday 14:00–15:25 Location: H6

Invited Talk VA 4.1 Mon 14:00 H6

Development of a new wireless SAW-Pirani vacuum sensor with extended range and sensitivity — •Sofia Toto and Juergen Brandner — Karlsruhe Institute of Technology

Vacuum sensors with a broad range are required for a number of applications. Many types of vacuum sensors already exist relying on various operating principles. One of their biggest drawback is their limited sensing range. In light of the recent technology and of the industry requirements, a new sensor aiming to sense a broader vacuum range extending from atmospheric pressure down to high vacuum has been developed. It uses state of the art microelectronics enabling efficient wireless power and signal transfer, resistant and stable materials that prevent outgassing and micromachining that allows a compact stable packaging in vacuum.

The sensor operates based on the Pirani principle and Surface Acoustic Waves (SAW-Pirani principle). A piezoelectric chip located inside a channel inserted in a vacuum environment is heated. The heat loss of the chip to its ambient through gas conduction is proportional to the number of molecules in the vacuum system. Temperature variations of the chip due to pressure changes in the vacuum chamber are detected by the change in frequency values of a crossing surface acoustic wave propagating on the surface of the chip via an interdigitated transducer. An interrogation signal is sent to the Interdigitated Transducer (IDT) and the frequency shift due to the pressure is recorded by the reflected signal. The vacuum pressure can therefore be calculated from the temperature of the heated body.

VA 4.2 Mon 14:40 H6

Combined total - partial pressure sensor — •Mihail Granovskij, Sergej Uchatsch, Klaus Bergner, Michael Flämmich, and Ute Berger — VACOM Vakuum Komponenten und Messtechnik GmbH, In den Brückenäckern 3, 07751 Großlöbichau

The recent progress in the development of a vacuum gauge with an integrated He-leak detector based on a novel ion source will be presented.

The fundamental idea of the vacuum gauge is the novel measuring principle: Instead of directly measuring the ion current, ions are accumulated inside an electron space charge region. The total pressure in the chamber is determined by the accumulation time that is necessary to collect a certain amount of ions. Thereby the capacity of the ion trap is independent from the prevailing pressure and is exclusively determined by the space charge density.

Furthermore, a short time-of-flight (TOF) path is connected to the ion source. On this route, the collected ions are separated according to their masses and measured at the Faraday Cup detector in a time separated manner. This enables the gauge to measure the residual gas composition. In particular a Helium leakage test can be carried out.

In the talk the underlying physical principles of the novel ion source are presented along with numerous experimental results. Next to total pressure and low mass spectrum measurements, the capability of analyzing the gas composition up to 50 m/z at high repetition rates is evaluated. Use cases for different final applications will be discussed.

15 min. break

VA 5: Vacuum Measurement in Technical Applications

Time: Monday 15:25–17:05 Location: H6

Invited Talk VA 5.1 Mon 15:25 H6

Outgassing rate measurements in practice: feasibility and comparability — •Michael Flämmich[1], Francisc Haidu[1], Christian Worsch[1], Marcel Klessen[2], Klaus Bergner[1], and Ute Bergner[1] — [1]VACOM Vakuum Komponenten & Messtechnik GmbH, Germany — [2]TREAMS GmbH, Germany

Outgassing rate measurements have long been utilized for the qualification of the vacuum suitability of materials in laboratories worldwide. At VACOM these measurements are fully integrated in the process chain of the production and cleaning of vacuum components. By this means, outgassing rate measurements are routinely performed with residual gas analysis (RGA) systems (utilizing either the throughput or the box-in-box method) in order to verify the cleanliness of the parts, components and assemblies. In order to perform reliable, comparable and quantitative RGA measurements utilizing different RGA systems/tools, each system/tool itself needs to be calibrated, where the calibration or rather the adjustment of the utilized quadrupole mass spectrometer (QMS) is finally tipping the scales.

In this talk, we present some results of a comparison of different types of commercially available QMS that have been investigated with respect to their feasibility in qualitative and quantitative outgassing rate measurements. Although these QMS exhibit relevant differences in design (e.g. ion source, single-/double-/triple-filter, rod system, ...) that yield serious differences in their characteristics (e.g. dynamic range, (mass specific) sensitivity, detection limit, ...), it was possible to adjust these QMS to a comparable performance in RGA measurements.

VA 5.2 Mon 16:05 H6

Improved model for transmission probabilities of edge-welded bellows based on TPMC simulations — •Marcel Krause and Joachim Wolf — Karlsruhe Institute of Technology (KIT), Wolfgang-Gaede-Str. 1, 76131 Karlsruhe, Germany

Edge-welded bellows are a frequently used component of many complex vacuum systems. Simulating these bellows in the regime of molecular flow with a Test Particle Monte Carlo (TPMC) algorithm is often time-consuming and CPU-intensive. By investigating the change of the transmission probability of bellows in comparison to cylindrical tubes for a large range of geometry parameters of both the bellows and the tubes, we developped an empirical model for the transmission probability of edge-welded bellows. This new model allows to replace edge-welded bellows in TPMC simulations with cylindrical tubes with an effective length to account for the transmission probability of the bellow. We found that the replacement of a bellow with a cylindrical tube decreased the simulation time by factors up to 1000, while the error introduced through the replacement was in most cases negligible.

VA 5.3 Mon 16:35 H6

Modern Mass Spectrometry in Vacuum Applications using LEYSPEC RGAs — •Stefan Lausberg — Leybold GmbH, Bonner Str. 498, 50968 Köln, Germany

In vacuum applications it is essential to keep the process or ultimate pressure at a distinct level. For some cases it is sufficient to consider the total pressure. However, in many vacuum applications it is even more important to keep the partial pressure of a certain substance at a distinct threshold. Parts treated in vacuum furnaces are very sensitive to enhanced amounts of oxygen. Optical thin film production requires a low enough partial pressure of water and the absence of hydrocarbons. This is where residual gas analyzers (RGA) come into play.

Here we present the new Leybold RGAs, the so-called LEYSPEC VIEW and LEYSPEC ULTRA. These quadrupole mass spectrometers (QMS) cover a range of atomic masses up to 300 amu. They can be provided suitable for bake-out temperatures of up to 300°C and operation temperatures of up to 250°C. The all-in-one devices with integrated control and display can be operated even without connecting them to a computer. A programmable degas function is implemented for degassing after start or exposure to atmosphere. For more advanced test procedures Leybold provides an intuitive software that can be used as a process gas monitor. Different amounts of atomic masses can be entered into recipes that can be identified by the RGA. We outline the utilization of LEYSPEC RGAs in different vacuum applications and their integration into turbomolecular pumping systems forming stand-alone devices.

VA 6: Annual General Meeting of the Vacuum Science and Technology Division

Time: Monday 17:15–18:00 Location: H6

Duration 45 min.