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

Gerhard Voss
Vacuum Academy
Oerlikon Leybold Vacuum GmbH
Bonner Str. 498
50968 Köln
gerhard.voss@oerlikon.com

Overview of Invited Talks and Sessions

(Lecture Rooms H6)

Invited Talks

VA 1.1	Mon	10:00–10:40	H6	**The Birth of a New Turbo-Molecular Pump** — •Martin Tollner
VA 1.3	Mon	11:00–11:40	H6	**Redefinition of a 60 years old barrier: simple Bayard-Alpert gauge beats the X-ray limit** — Jaroslaw Iwicki, Marco Walter, Heiko Wunderlich, •Michael Flämmich, Ute Bergner
VA 2.1	Mon	14:00–14:40	H6	**Transient rarefied gas flow through short channels at arbitrary pressure ratios** — •Stylianos Varoutis, Christian Day

Sessions

VA 1.1–1.4	Mon	10:00–12:00	H6	**Future Requirements on Vacuum Pumps and Vacuum Gauges**
VA 2.1–2.1	Mon	14:00–14:40	H6	**Transient rarefied Gas Flow through short Channels**
VA 3.1–3.1	Mon	14:40–15:00	H6	**Desorption**
VA 4.1–4.3	Mon	15:00–16:00	H6	**Vacuum Systems and Tools**
VA 5.1–5.1	Wed	13:15–13:55	H15	**Gaede-Prize Talk Kirsten von Bergmann**

VA 1: Future Requirements on Vacuum Pumps and Vacuum Gauges

Time: Monday 10:00–12:00 Location: H6

Invited Talk VA 1.1 Mon 10:00 H6

The Birth of a New Turbo-Molecular Pump — •Martin Tollner — Oerlikon Leybold Vacuum, 50968 Cologne, Germany

From the initial market requirement specification to product launch the process of developing a new turbo-molecular pump for the vacuum market is full of complex engineering challenges. The on-going requirement to always have better performance, lower cost and improved reliability pushes engineers to continuously improve their methods of work. Striving to improve turbo-molecular pump performance requires state of the art engineering modelling tools, which in some cases are not commercially available. To maximise pumping performance, pumping mechanism modelling tools are required to accurately model and optimise a pump design for a variety of gas types across the molecular, transitional and viscous flow regimes. Also a detailed understanding of material properties as well as rotor stress simulation is required to increase performance by increasing rotational speed and blade velocities. Thermal limitations usually dictate the performance envelope of a pump, therefore the ability to accurately model and understand the thermal behaviour of a pump is the key to enhancing the performance envelope. Once the initial design concept is proven, there is a detailed series of validation, compliance and reliability testing required to ensure the product is safe and reliable before product launch. This talk aims to give an overview of the various methods, tools and processes used to develop a world class turbo molecular pump from requirement through to product launch.

VA 1.2 Mon 10:40 H6

A metal foil vacuum pump for the fuel cycle of fusion power plants — •Thomas Giegerich and Christian Day — Karlsruher Institut für Technologie (KIT), Institut für Technische Physik (ITEP), Eggenstein-Leopoldshafen, D-76344, GERMANY

At KIT Karlsruhe, a new vacuum pump based on the physical principle of superpermeation is under development. This metal foil pump shall be used in the fuel cycle of a fusion reactors and forms the central part of the Direct Internal Recycling concept (DIR), a shortcut between the machine exhaust pumping and the fuelling systems.

This vacuum pump simplifies the fusion fuel cycle dramatically and provides two major functions simultaneously: A separating and pumping function. It separates a hydrogen isotopes and impurities containing gas flow sharply into a pure H-isotopes flow that is also being compressed. The remaining impurity enriched gas flow passes the pump without being pumped.

For superpermeability, a source of molecular hydrogen is needed. This can be achieved by different methods inside of the pump. Most important are plasma based or hot rod (atomizer) based methods.

In this talk, the physical working principle and the modeling of this pump is presented and the development towards a technical separator pumping module is shown up.

Invited Talk VA 1.3 Mon 11:00 H6

Redefinition of a 60 years old barrier: simple Bayard-Alpert gauge beats the X-ray limit — Jaroslaw Iwicki, Marco Walter, Heiko Wunderlich, •Michael Flämmich, and Ute Bergner — VACOM Vakuum Komponenten & Messtechnik GmbH, Gabelsbergerstraße 9, 07749 Jena, Germany

Since the invention of the Bayard-Alpert (BA) hot cathode ionization gauge in 1950 there is a continuous trend with increasingly challenging effort to improve the lower pressure measurement limit. In this regard, several attempts with rather complex setups have been made in the past. In this contribution a standard-like BA gauge is discussed with dedicated focus to accuracy and reproducibility in the lower pressure measurement range. BA gauges deliver a minor residual current that is inherent to the design of the sensor and that defines the lower measurement limit of the gauge. An investigation of the basic physical processes that contribute to the residual currents in BA gauges yields a novel approach to minimize the residual current in BA gauges directly in the sensor while keeping the simple and established BA setup. Experimental results of a new BA gauge with a compensation of the residual current (BARION XHV) show an extended lower measurement limit by two decades down to XHV and a significantly increased accuracy in the pressure range 1E-9...1E-11 mbar. Due to a respective design, furthermore, an improved reproducibility is ensured.

VA 1.4 Mon 11:40 H6

Si-Feldemissionskathoden für Anwendungen in miniaturisierten Ionisationsvakuumsensoren — •Christoph Langer[1], Christian Prommesberger[1], Florian Dams[1], Pavel Serbun[2], Benjamin Bornmann[2], Stephan Mingels[2], Günter Müller[2] und Rupert Schreiner[1] — [1]Fakultät Mikrosystemtechnik, Hochschule Regensburg — [2]Fachgruppe Physik, Bergische Universität Wuppertal

Feldemissionselektronenquellen sind aufgrund ihrer prinzipiellen Vorteile gegenüber Glühkathoden bereits seit längerer Zeit Gegenstand der Forschung und werden bisher nur in einigen Spezialanwendungen erfolgreich eingesetzt. Hierbei werden Einzelspitzen mit Spannungen im kV-Bereich und Strömen im nA-Bereich betrieben. Dagegen werden für miniaturisierte Sensorsysteme eher Spannungen von ca. 100 V und Ströme von ca. 1 mA benötigt. Dazu wurden bisher meist Feldemissionskathoden mit CNTs vorgeschlagen, welche für Anwendungen in der Halbleiterindustrie aufgrund des Kohlenstoffanteils nicht erwünscht sind. Ziel unserer Arbeit ist es, Si-basierte Elektronenquellen zu realisieren, die mit anderen miniaturisierten Vakuumsensoren auf einem Chip integrierbar sind. Mithilfe eines optimierten Herstellungsprozesses konnten wir p-Si-Spitzenarrays mit Spitzenradien von wenigen nm realisieren [1]. Messungen an diesen Strukturen zeigen ein sehr homogenes Emissionsverhalten, das vor allem im Sättigungsbereich bei Emissionsströmen von ca. 10 nA pro Spitze zeitlich stabil (Schwankungen < 5 %) und optisch schaltbar (Faktor > 2.5) ist [2].

[1] F. Dams, IEEE Trans. Electron Devices 59 (10), 2832-2837 (2012)
[2] P. Serbun, J. Vac. Sci. Technol. B 31 (2), 02B101 (2013)

VA 2: Transient rarefied Gas Flow through short Channels

Time: Monday 14:00–14:40 Location: H6

Invited Talk VA 2.1 Mon 14:00 H6

Transient rarefied gas flow through short channels at arbitrary pressure ratios — •Stylianos Varoutis and Christian Day — Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

Steady state flows of rarefied gases through orifices, slits, short tubes, and channels are well studied. In spite of the high practical interests to the transient flows of rarefied gases, the problem of short channel (i.e. parallel plates) flow has not been studied from this point of view. The aim of the present work is to study transient rarefied gas flow through a short channel based on the direct simulation Monte Carlo method. The mass flow rate and corresponding macroscopic parameters in the inlet and outlet of the channel, are calculated as a function of the time and the gas rarefaction. Two values of the pressure ratio, i.e., 0 and 0.5, and two values of the length-to-height aspect ratio, i.e. 1 and 5, are considered. A characteristic time equal to the one a particled needs to cross the channel height with the most probable molecular speed is introduced. The typical time to establish the stationary flow is presented as well.

VA 3: Desorption

Time: Monday 14:40–15:00 Location: H6

VA 3.1 Mon 14:40 H6

Influence of the pre-treatment on outgassing — •Katharina Battes and Volker Hauer — Karlsruhe Institute of Technology (KIT), 76344 Eggenstein-Leopoldshafen, Germany

As outgassing plays an important role in vacuum technology, it is essential to know the outgassing rates of the different materials being used in vacuum systems.

In literature for plenty of materials outgassing rates can be found. But because of different treatments of the sample before measurement, the outgassing rates often differ over some decades. An important issue here is the baking temperature and time, but also surface treatments like cleaning, electro-polishing and coating as well as the pump down history vary and have a high influence on the results.

To further examine how the diverse treatments are taken into account, outgassing measurements of variably treated stainless steel samples (SS 304) are performed at the new Outgassing Measurement Apparatus (OMA) at KIT. At OMA the difference method is used so that with the subtraction of the chamber outgassing also very small outgassing rates can be measured.

The configuration of the Outgassing Measurement Apparatus as well as the results of the measurements in comparison with those obtained from literature will be presented within this talk.

VA 4: Vacuum Systems and Tools

Time: Monday 15:00–16:00 Location: H6

VA 4.1 Mon 15:00 H6

Thin film combinatorial libraries for materials research — •Andrei Ionut Mardare and Achim Walter Hassel — Institut für Chemische Technologie Anorganischer Stoffe, Johannes Kepler Universität Linz, 4040, Altenberger Str.69, Linz, österreich

Many novel materials are developed nowadays by using combinatorial methods. The present work presents a much cheaper alternative to co-sputtering for the preparation of thin film combinatorial libraries by using a state of the art thermal co-evaporator. Three different thermal sources can be used simultaneously in a self-made system. The usual high cost water cooled electrical feedthroughs providing the high currents necessary for the thermal elements are successfully replaced by Cu rods externally attached to cost effective computer processor coolers. The background vacuum level is 10-7mbar ensuring a low contaminants level during the film formation. Using crystal quartz balances, the flux of each source can be individually controlled and the desired compositional gradient can be obtained by adjusting the evaporation power. Moreover, each source can be individually moved in the vertical plane so that the source-substrate distance can be adjusted for each element. This action will affect the individual thickness gradients through the cosine law of evaporation giving the user an extra degree of freedom for tuning the final library composition. A wide range of pure metals can be used as sources as well as semiconducting materials such as Si or oxides such as WO3 or MoO3. The use of alloys such as AlCu or MgZn as a single evaporation source was also successfully tested opening the door toward quaternary combinatorial libraries.

VA 4.2 Mon 15:20 H6

Empfindliche Lecksuche mit Kältemittel als Spürgas — •Baker Farangis und Wolfgang Jitschin — TH Mittelhessen, Campus Gießen

Undichtigkeiten an Vakuumsystemen lassen sich mit verschiedenen Lecksuchenmethoden lokalisieren. Eine Methode ist die Überdruck-Lecksuche, bei der die zu prüfenden Komponenten mit einem Spürgas unter Überdruck gesetzt werden und das an der Leckstelle austretende Gas gemessen wird. Das Spürgas sollte ungiftig, preisgünstig und gut nachweisbar sein. Geeignete Gase sind H2, He aber auch (verdünnte) Kältemittel wie z.B. R134a. Helium hat den Nachteil, dass ein einfacher Nachweis (Wärmeleitung) nur geringe Empfindlichkeit bietet und ein empfindlicher Nachweis (Massenspektroskopie) großen Aufwand erfordert. Dagegen können Kältemittel vom Typ der halogenierten Kohlenwasserstoffe auf einfache Weise empfindlich und selektiv durch Ausnutzung der gasspezifischen IR-Absorption detektiert werden, da die Vibrationszustände im Wellenlängenbereich 6,7 ... 10 mikrometer liegen. Typische kommerzielle Gasschnüffler bestehen aus breitbandiger IR-Lichtquelle mit nachgeschaltetem Interferenzfilter, Gaszelle und Passiv-IR-Sensor und erreichen eine Nachweisgrenze von ca. 3g/a oder 2E-5 mbar*l/s. An der TH-Mittelhessen werden Kältemittel-Leckschnüffler nach DIN 14624:2012 geprüft. Zur Bestimmung der Nachweisgrenze wird die Schnüffelsonde unter festgelegten Bedingungen an Kalibrierlecks vorbeigeführt und die Reaktion des Schnüfflers registriert. Die Leckrate der verwendeten Kalibrierlecks wird durch Gravimetrie und direkter Gasstrommessung überwacht.

VA 4.3 Mon 15:40 H6

Pumping Systems for Ultra and Extreme High Vacuum Level — •Enrico Maccallini, Andrea Cadoppi, and Paolo Manini — SAES Getters S.p.A, viale Italia 77, 20020, Lainate (Mi), Italy.

Nowadays, Ultra and Extreme High Vacuum (UHV and XHV respectively) levels are increasingly required in several vacuum-related systems (i.e., Surface Science, Thin Film Deposition, Cold Atomic Trap, Portable Systems, Electron Microscopes, Particle Accelerator and Synchrotron Radiation Source).

Non Evaporable Getter (NEG) pumps are one of the possible technical options to get XHV/UHV in the vacuum systems. The achievement of XHV/UHV is possible thanks to the high reactivity of the getter materials towards active gases such as H2, H2O, CO2, CO, O2, N2. If the getter material is saturated, the pumping speed of NEG pumps can be easily restored by a reactivation process which can be carried out in a short period (approximately 1-2 hours) and with low power consumption.

Experimental results achieved by NEG pump technology in combination with other pumping systems are presented. The benefits of using NEG pumps in XHV/UHV systems are highlighted in terms of fast pumpdown, large pumping speed for hydrogen, possible reduction of bake out time and baking temperature, reduction of magnetic interference and portability.

VA 5: Gaede-Prize Talk Kirsten von Bergmann

Time: Wednesday 13:15–13:55 Location: H15

Prize Talk VA 5.1 Wed 13:15 H15

Complex magnetic order on the atomic scale — •Kirsten von Bergmann — Institute of Applied Physics, University of Hamburg

Magnetism in low-dimensions is a versatile topic and broken inversion symmetry due to the presence of a surface can induce the formation of complex magnetic order. Here the driving force for the canting of adjacent magnetic moments is the spin-orbit induced Dzyaloshinskii-Moriya interaction. Thin magnetic films on heavy substrates are good candidates for this kind of surface-induced non-collinear magnetic states with unique rotational sense.

Spin-polarized scanning tunneling microscopy (SP-STM) combines magnetic sensitivity with high lateral resolution and therefore grants access to such complex magnetic order with unit cells on the nanometer scale. Several non-collinear magnetic ground states, such as spin spirals where the spin rotates from one atom to the next, habe been observed [1-3]; while in uniaxial systems only one propagation direc-

tion is found, in biaxial systems rotational domains of spin spirals are present. In the case of the monolayer Fe on Ir(111) a combination of different magnetic interactions, including higher-order interactions, leads to a two-dimensional lattice of magnetic skyrmions on the atomic scale [4,5].

[1] M. Bode et al., Nature 447, 190 (2007).
[2] P. Ferriani et al., Phys. Rev. Lett. 101, 27201 (2008).
[3] M. Menzel et al., Phys. Rev. Lett. 108, 197204 (2012).
[4] K. von Bergmann et al., Phys. Rev. Lett. 96, 167203 (2006).
[5] S. Heinze et al., Nature Phys. 7, 713 (2011).