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

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Overview of Invited Talks and Sessions

(Lecture room: HSZ 105)

Invited Talks

VA 1.1	Mon	10:00–10:40	HSZ 105	**Development of a novel mechanical bearing turbomolecular pump for research and analytical applications** — •Ernst Schnacke
VA 1.2	Mon	10:40–11:20	HSZ 105	**Revival of mercury diffusion pumps - A new, compact design for fusion applications** — •Thomas Giegerich, Christian Day, Xueli Luo, Ralf Müller, Santiago Ochoa, Matthieu Scannapiego, Holger Strobel
VA 2.1	Mon	14:00–14:40	HSZ 105	**Pirani type microsensors for pressure measurements from 10^3 mbar to 10^{-6} mbar** — •Mario Grau, Friedemann Völklein, Andreas Meier, Christina Kunz, Lars Breuer, Peter Woias

Sessions

VA 1.1–1.4	Mon	10:00–12:00	HSZ 105	**Vacuum Generation**
VA 2.1–2.3	Mon	14:00–15:20	HSZ 105	**Vacuum Gauges and Instrumentation**
VA 3.1–3.3	Mon	15:40–16:40	HSZ 105	**Vacuum based Manufacturing, Coating and Analysis**

VA 1: Vacuum Generation

Time: Monday 10:00–12:00 Location: HSZ 105

Invited Talk VA 1.1 Mon 10:00 HSZ 105

Development of a novel mechanical bearing turbomolecular pump for research and analytical applications — •Ernst Schnacke — Oerlikon Leybold Vacuum GmbH

The requirements for turbomolecular pumps in research and analytics tend towards higher efficiency for light gasses, high reliability, and user friendly integration in systems and their controls. The presentation shows a discussion of existing bearing concepts and an evaluation of advantages/disadvantages. The chosen bearing concept then was optimized for longest lubrication lifetime. A computing methods were developed to optimize rotor/stator geometry for varying requirements for high pumping speed, compression, and gas dependency. The result is a gain of at least 30% efficiency for same diameter. Fully integrated electronics gave further opportunity to reduce power consumption and cooling requirement.

Invited Talk VA 1.2 Mon 10:40 HSZ 105

Revival of mercury diffusion pumps - A new, compact design for fusion applications — •Thomas Giegerich, Christian Day, Xueli Luo, Ralf Müller, Santiago Ochoa, Matthieu Scannapiego, and Holger Strobel — Institute for Technical Physics (ITEP), Karlsruhe Institute of Technology (KIT), Campus Nord, Eggenstein-Leopoldshafen, D-76344

The fuel cycle of fusion power plants with several hours long plasma pulses poses a large challenge for the vacuum pumping systems, especially for the primary pumps. Large amounts of radioactive and chemically reactive gases (tritium) must be processed under rough working conditions: The pumps must work under strong magnetic fields, neutronic radiation and in an atmosphere where dust is present. Furthermore, it must be practically maintenance-free and fulfil high safety requirements. As only feasible pumps for this task, diffusion pumps have been identified. Nowadays, diffusion pumps with oil as working fluid are easily available in the required pumping speeds (some 10'000 l/s), but, unfortunately, oil cannot be used for tritium processing as it would decompose. This is why a large diffusion pump with mercury as working fluid is currently under development at KIT. Mercury as perfectly tritium compatible working fluid was already used in the early years of the diffusion pump, which celebrates its 100 birthday next year. This talk presents the latest results of the pump development procedure including the latest simulation results as well as thermal and mechanical analyses of the current pump design.

VA 1.3 Mon 11:20 HSZ 105

Vakuumsimulationen des KATRIN-Experimentes — •Marcel Krause — Karlsruher Institut für Technologie (KIT), IEKP, Postfach 3640, 76021 Karlsruhe

Das <u>KA</u>rlsruhe <u>TRI</u>tium <u>N</u>eutrinomassenexperiment (KATRIN) am Karlsruher Institut für Technologie (KIT) hat sich zum Ziel gesetzt, die Neutrinomasse durch den Tritium-β-Zerfall mit einer bisher unerreichten Sensitivität von $m_\nu < 0,2\,\mathrm{eV/c^2}$ zu messen. Der Zerfall findet hauptsächlich in der fensterlosen, gasförmigen Tritiumquelle (WGTS) statt. Die Elektronen werden magnetisch durch die Pump- und Transportstrecke geführt. Dort wird das restliche Tritiumgas mit Hilfe einer differentiellen Pumpstrecke aus kaskadierten TMPs und einer Kryopumpstrecke mit einer desorbierenden Oberfläche aus 3 K Argonschnee entfernt. Eine weitere, zentrale Komponente ist das elektrostatische Hauptspektrometer, mit dem die Energie der β-Elektronen gemessen wird. Es besteht aus einem 24 m langen UHV-Rezipienten mit einem Volumen von $1240\,\mathrm{m^3}$ und einer inneren Oberfläche von $1150\,\mathrm{m^2}$. Der angestrebte Druck von 10^{-11} mbar soll mit 6 TMPs und drei Getterpumpen aus insgesamt 3000 m St707 NEG-Streifen erzeugt werden. Außerdem sollen geringe Spuren von Radon, die aus der Tankwand und aus dem NEG-Material austreten, mit LN_2-Baffels desorbiert werden. Im Vortrag wird über die Simulation der Komponenten im Molekularströmungsbereich berichtet. Die Simulationen wurden mit den Programmen MOLFLOW und PROVAC3D durchgeführt. Teilweise gefördert vom BMBF unter den Förderkennzeichen 05A11VK3.

VA 1.4 Mon 11:40 HSZ 105

Vakuummessungen mit dem KATRIN-Hauptspektrometer — •Joachim Wolf — Karlsruher Institut für Technologie (KIT), IEKP, Postfach 3640, 76021 Karlsruhe

Das <u>KA</u>rlsruhe <u>TRI</u>tium <u>N</u>eutrinomassenexperiment (KATRIN) am Karlsruher Institut für Technologie (KIT) hat sich zum Ziel gesetzt, die Neutrinomasse durch den Tritium-β-Zerfall mit einer bisher unerreichten Sensitivität von $m_\nu < 0,2\,\mathrm{eV/c^2}$ zu messen. Ein zentrale Komponente ist das elektrostatische Hauptspektrometer, mit dem die Energie der β-Elektronen in der Umgebung des Endpunktes bei 18,6 keV mit hoher Präzision gemessen wird. Es besteht aus einem 24 m langen UHV-Rezipienten mit einem Volumen von $1240\,\mathrm{m^3}$ und einer inneren Oberfläche von $1150\,\mathrm{m^2}$. Knapp die Hälfte der Oberfläche stammt von einem komplexen Drahtelektrodensystem aus ca. 120 000 Einzelteilen. Die Sensitivität der Messung hängt von einer niedrigen Untergrundrate ab, die ihrerseits von der Qualität des Vakuums abhängt. Der angestrebte Druck von 10^{-11} mbar soll mit 6 TMPs und drei Getterpumpen aus insgesamt 3000 m St707 NEG-Streifen erzeugt werden. Außerdem sollen geringe Spuren von Radon, die aus der Tankwand und aus dem NEG-Material austreten, mit LN_2-Baffels desorbiert werden, um die Rn-Zerfallsrate im Spektrometervolumen auf ca. einen Zerfall pro Tag zu reduzieren. Im Vortrag wird über den Aufbau, die Inbetriebnahme und die Vakuummessungen während des Spektrometerbetriebs in 2013 berichtet. Teilweise gefördert vom BMBF unter den Förderkennzeichen 05A11VK3 und 05A11PM2.

VA 2: Vacuum Gauges and Instrumentation

Time: Monday 14:00–15:20 Location: HSZ 105

Invited Talk VA 2.1 Mon 14:00 HSZ 105

Pirani type microsensors for pressure measurements from 10^3 mbar to 10^{-6} mbar — •Mario Grau[1,2], Friedemann Völklein[1], Andreas Meier[1], Christina Kunz[1], Lars Breuer[1], and Peter Woias[2] — [1]RheinMain University of Applied Sciences, Wiesbaden — [2]University of Freiburg, Dept. of Microsystems Engineering

Conventional thermal conductivity vacuum gauges cover a measurement range from typically 100 mbar to 10^{-3} mbar. By miniaturization of such sensors it is possible to significantly expand the sensitivity range. Heat flux to the surrounding gas depends on pressure and should be maximized to achieve high sensitivity, whereas the heat losses by radiation and solid thermal conduction have to be minimized. Design optimization leads to sensors with large area suspended membranes with reduced emissivity for the high vacuum range. In contradiction to this approach, we use small area suspended membranes for the rough vacuum range in order to minimize the required heating power. Furthermore small gaps in the order of 10 micrometers are necessary for the improvement of sensitivity in the rough vacuum range. Therefore,we have developed two specific microchips. The first one (VAC_03) is designed for the pressure range from 10^{-6} mbar to 1 mbar and the second one (VAC_04) for the range from 10^{-3} mbar to 10^3 mbar. The chip size of the VAC_04 is very small (1x1 mm) and can be integrated into the housing of the VAC_03 sensor. We present FEM Simulations of the various heat flux mechanisms, chip design and signal voltage versus pressure for the optimized microchips.

VA 2.2 Mon 14:40 HSZ 105

Comparison of different mass spectrometers for fusion applications — •Katharina Battes, Christian Day, and Volker Hauer — Karlsruhe Institute of Technology (KIT), 76344 Eggenstein-Leopoldshafen, Germany

For fusion applications, like e. g. for analysing tokamak exhaust gases, mass spectrometers could be used. But as the plasma pulses can be short (e.g. about 400 s for ITER), fast responding devices are needed. On the other hand also devices with a high resolution as well as a low detection limit are required, as He and D2 should be separated and small contents of impurities should be detected, respectively.

The fast response time can e.g. be achieved by an autoresonant ion trap mass spectrometer (Brooks 835 VQM), which can determine partial pressures from 1-300 amu in 120 ms. Like this online measurements are possible, but the fast scan time leads to a lack of resolution and sensitivity. Therefore a second device, a high resolution quadrupole mass spectrometer (Balzers GAM 400), is used for accurately determining partial pressures of different exhaust gases. Even He and D2 which both appear at a mass of about 4 amu can be separated and quantified. However, such a scan can only be performed a few times during a short pulse. As third device another QMS (MKS Microvision 2) is going to be tested. It operates only in the mass range from 1-6 amu and there achieves very high resolution.

This paper will present comparative measurements of expected exhaust gases and discuss the applicability of these three devices for online-mass spectrometry.

VA 2.3 Mon 15:00 HSZ 105

Synthesis and investigation of advanced materials based on low-dimensional systems by fast XPS — •Sergey Babenkov[1], Olga Molodtsova[1], Victor Aristov[1,2], Frank Scholz[1], Joern Seltmann[1], Ivan Shevchuk[1], Leif Glaser[1], and Jens Viefhaus[1] — [1]DESY, Hamburg, Germany — [2]ISSP RAS, Chernogolovka, Russia

Generally the synthesis and consequently many properties of advanced materials involve fast reaction processes, which should be precisely controlled and characterized. We propose fast electron spectroscopy for this task. The end-station for such investigations was designed, built up and installed into the soft X-ray beamline P04 at PETRA III (DESY Hamburg). The system is based on a hemispherical electron spectrometer ARGUS (Omicron NanoTechnology) with parallel detection, which in combination with the high brilliance of PETRA III at XUV beamline P04 provides the possibility of taking extremely fast (below 1 sec/spectrum) soft x-ray photoelectron spectra of high quality.

Using such unique set-up first of all we have studied the process of graphene formation by control the time/temperature/rare-gas pressure parameters. In addition we present metal-organic interface formation by in-situ indium deposition onto thin organic molecular crystal (CuPcF4) at room temperature conditions.

VA 3: Vacuum based Manufacturing, Coating and Analysis

Time: Monday 15:40–16:40 Location: HSZ 105

VA 3.1 Mon 15:40 HSZ 105

A 4K-UHV-Cryostat-System for Magnetic Exchange Force Microscopy with a 2-Axes-Vector-Field Magnet — •Lasse Cornils, René Schmidt, Alexander Schwarz, and Roland Wiesendanger — Institute of Applied Physics, University of Hamburg, Jungiusstrasse 11, 20355 Hamburg, Germany

Magnetic exchange force microscopy (MExFM) is utilized to study magnetic ordering with atomic resolution and single spin sensitivity in real space [1]. Being able to apply a rotatable magnetic field allows to study magnetic anisotropy effects of complex spin structures or single magnetic atoms on surfaces. Therefore an existing ultra high vacuum (UHV) cryostat [2] was equipped with a 2-axes vector field magnet allowing to apply 6T out-of-plane (z-direction) and 2T in-plane (x-direction). Up to 2T can be applied in any direction in the xz-plane. The performance of the microscope is demonstrated by atomic resolution measurements on NaCl(100).

Moreover, new features to prepare clean samples were added to the original UHV-system, e.g. a new electron beam heating stage for controlled sample temperatures between room temperature and 1800 °C.

[1] U. Kaiser, *et al.*, Nature **446**, 522-525 (2007).

[2] W. Allers, *et al.*, Rev. Sci. Instrum. **69**, 221-225 (1998).

VA 3.2 Mon 16:00 HSZ 105

Glow discharge effects in a field emission vacuum chamber — •Daniela Wenger[1,2], Wolfram Knapp[3], Bernhard Hensel[2], and Sandro F. Tedde[1] — [1]Siemens AG, Corporate Technology, Erlangen, Germany — [2]Center for Medical Physics and Engineering, University Erlangen-Nuremberg, Germany — [3]Otto von Guericke University, Magdeburg, Germany

The field emission properties of SWCNT/graphene hybrid samples were investigated in diode mode in a high vacuum chamber (10^{-8} mbar). For the application in medical X-ray systems for e.g. mammography, long pulses of more than 100 ms are necessary. The maximum current, which was achieved with short pulses, reached 400 mA (0.8 A/cm^2). Here, IV characteristics were investigated with long pulse-on times up to 500 ms. The pulse-off time was varied, resulting in duty cycles between 0% (single pulse) and 100%.

During long voltage pulses of more than 100 ms, a significant increase of the current was measured. This indicates a secondary electron emission effect, which increases the initial field emission current. We assume that the field emission electrons ignite the glow discharge of the gas molecules in the gap between cathode and anode. The glow discharge can be observed as glowing plasma between cathode and anode. Since this gap is only 100 μm wide, the local pressure is probably much higher than the chamber pressure due to geometry and outgassing due to electron scattering at the anode.

Experimental evidences of avalanche discharges will be given. The local pressure will be calculated, based on observations of the plasma.

VA 3.3 Mon 16:20 HSZ 105

Using FN Plots to Characterize Tungsten Microemitters — •Andreas Fischer[1] and Marwan S. Mousa[2] — [1]Institut für Physik, TU Chemnitz, Chemnitz, Germany — [2]Department of Physics, Mu'tah University, Al-Karak, Jordan

Tungsten microemitter tips have been prepared at variable apex radii. Various properties of these emitters were measured including current-voltage characteristics and the physical shape of the tips. Experimental results are connected to the theory for analyzing Fowler-Nordheim (FN) plots. We derived the apex radii of the tips by both SEM imaging and analyzing FN plots. The aim of this analysis is to support the ongoing discussion on recently developed improvements of the theory for analyzing FN plots related to metal field electron emitters, which in particular introduces a new form of intercept correction factors. The results derived demonstrate the applicability of the applied method on needle shaped – i.e. non planar – emitters as well as its limits.