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

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Overview of Invited Talks and Sessions

(lecture room HSZ 101)

Invited Talks

VA 1.1	Mon	10:00–10:40	HSZ 101	**Cryogenic pumping for the fabrication of highest-purity semiconductors** — •Werner Wegscheider

Sessions

VA 1.1–1.2	Mon	10:00–11:00	HSZ 101	**Cryogenic Vacuum Pumping**
VA 2.1–2.3	Mon	11:00–12:00	HSZ 101	**Gas Flow Simulation**
VA 3.1–3.4	Mon	14:00–15:20	HSZ 101	**KATRIN Vacuum Systems**
VA 4.1–4.2	Mon	15:20–16:00	HSZ 101	**Vacuum Control and Monitoring**
VA 5.1–5.1	Wed	14:00–14:45	TRE Phy	**Gaede Prize talk (Philip Hofmann)**

Annual General Meeting of the Vacuum Science and Technology Division

Mon 16:10–16:40 HSZ 101

VA 1: Cryogenic Vacuum Pumping

Time: Monday 10:00–11:00 Location: HSZ 101

Invited Talk VA 1.1 Mon 10:00 HSZ 101
Cryogenic pumping for the fabrication of highest-purity semiconductors — •Werner Wegscheider — Laboratorium für Festkörperphysik, ETH Zürich, 8093 Zürich, Switzerland

Cryogenic capture pumps based on closed-cycle gaseous He refrigerators are extensively used in semiconductor industry due to their high pumping speed resulting in short pump down times of vacuum chambers. For highest-purity growth of semiconductor heterostructures, where molecular beam epitaxy (MBE) is the method of choice, background vacuum levels below 1E-12 mbar have to be reached. This requirement presents a major challenge for the design of such a MBE system in which cryogenic capture pumps are exclusively used. I will present the outline and results of a GaAs based MBE system which was specifically designed for the fabrication of highest-mobility two-dimensional electron gases. The performance of these structures, which represent the key ingredient for so-called high-mobility transitors (HEMTs), depends critically on the purity of the growing material and thus on the vacuum level in the growth chamber.

VA 1.2 Mon 10:40 HSZ 101
The cryogenic vacuum system of SIS100 at FAIR — •Stefan Wilfert, Andreas Krämer, Holger Kollmus, Lars Bozyk, Hartmut Reich-Sprenger, Egbert Fischer, Anna Mierau, Seong Yeub Shim, and Jan-Patrick Meier — GSI Helmholtzzentrum für Schwerionenforschung mbH, Planckstr. 1, 64291 Darmstadt, Germany

FAIR, Facility for Antiproton and Ion Research, is a new international accelerator facility for the research with antiprotons and ions. The accelerator complex will be built in Darmstadt (Germany) in cooperation with an international community of countries and scientists. The synchrotron SIS100 is the main working horse of the facility. This synchrotron, presently in its advanced planning phase at GSI, is designed for acceleration of high intensity, low charge state heavy ion and proton beams. The machine will have a circumference of about 1.1 km and utilise fast-ramped superconducting magnets. For this reason, about 80% of the whole beam pipe vacuum will be operated at cryogenic temperatures. In these cold sections, the cooling of the beam guidance magnets will be used simultaneously for cryopumping the beam pipes. We present an overview on the infrastructure of the cryogenic beam vacuum system of SIS100 and discuss some design details and special features.

VA 2: Gas Flow Simulation

Time: Monday 11:00–12:00 Location: HSZ 101

VA 2.1 Mon 11:00 HSZ 101
Systematic vacuum study of the ITER model cryopump by Test Particle Monte Carlo simulation — •Xueli Luo, Horst Haas, and Christian Day — Institute for Technical Physics, Karlsruhe Institute of Technology, P.O. Box 3640, 76021 Karlsruhe, Germany

The primary pumping systems on the ITER torus are based on eight tailor-made cryogenic pumps because not any standard commercial vacuum pump can meet the ITER working criteria. This kind of cryopump can provide high pumping speed, especially for light gases, by the cryosorption on activated charcoal at 4.5K. In this paper we will present the systematic Monte Carlo simulation results of the model pump in a reduced scale by ProVac3D, a new Test Particle Monte Carlo simulation program developed by KIT. The simulation model has included the most important mechanical structures such as sixteen cryogenic panels working at 4.5K, the 80K radiation shield envelope with baffles, the pump housing, inlet valve and the TIMO (Test facility for the ITER Model Pump) test facility. Three typical gas species, i.e., deuterium, protium and helium are simulated. The pumping characteristics have been obtained. The result is in good agreement with the experiment data up to the gas throughput of 1000 sccm, which marks the limit for free molecular flow. This means that ProVac3D is a useful tool in the design of the prototype cryopump of ITER. Meanwhile, the capture factors at different critical positions are calculated. They can be used as the important input parameters for a follow-up Direct Simulation Monte Carlo (DSMC) simulation for higher gas throughput.

VA 2.2 Mon 11:20 HSZ 101
Follow-up vacuum study of the ITER model cryopump by the Direct Simulation Monte Carlo method — •Stylianos Varoutis[1], Felix Sharipov[2], Christian Day[1], Xueli Luo[1], and Horst Haas[1] — [1]Karlsruhe Institute of Technology (KIT), Institute for Technical Physics (ITeP), KIT Campus Nord, Hermann-von-Helmholtz-Platz 1, 76344, Eggenstein-Leopoldshafen, Germany — [2]Departamento de Física, Universidade Federal do Paraná, Caixa Postal 19044, Curitiba 81531-990, Brazil

The aim of the present work is a numerical modeling of the ITER model cryopump combining both DSMC and TPMC methods. The complicated flow configuration of cryopanels is modelled using the TPMC method since the intermolecular collisions can be neglected, while the remaining part of the cryopump is modelled with the DSMC method using as input the data obtained by the former approach. A detailed comparison with the corresponding experimental data is performed, which demonstrates the reliability of the computational tool. The numerical results provide detailed information about the gas flow field such as pressure distribution, number of particles and energy flux absorbed by each cryopanel, etc. These quantities can be used to optimize the pumping system in order to improve its performance.

VA 2.3 Mon 11:40 HSZ 101
3d-neutralgas simulation for vacuum facilities — •Robert Henrich, Michael Bachmann, Davar Feili, and Christian Heiliger — I. Physikalisches Institut, Justus Liebig University Giessen, D-35392, Germany

We present a three-dimensional simulation program for molecular gas flows at low pressures (high/ultrahigh vacuum). This program is designed to simulate the neutral gas distribution in any vacuum chamber with a size of a few centimeters up to a few meters. This can be used to optimize the pumping and/or gas distribution system for different applications. The main feature of the program is its ability of importing any arbitrary surface geometry that can be created in a CAD-program. Thereby the geometry will be converted to triangles. Once the geometry is imported each surface region can be assigned with special properties. At the moment gas inlets and pumps can be simulated and also appointing a specific surface temperature and specular/diffuse reflection coefficient is supported. With the actual version it is possible to simulate the distribution of the neutral gas and the influence of different pump arrangements on it. Furthermore the simulation is possible to calculate the neutral gas molecular flow transmission coefficients for arbitrary formed tubes.

VA 3: KATRIN Vacuum Systems

Time: Monday 14:00–15:20 Location: HSZ 101

VA 3.1 Mon 14:00 HSZ 101

Tritiumnachweis per β-induzierter Röntgenspektroskopie — •Marco Röllig — Für die KATRIN Kollaboration, KIT, IEKP, Karlsruhe, Deutschland

Das KArlsruher TRItium Neutrino-Experiment KATRIN untersucht spektroskopisch das Elektronenspektrum des Tritium β-Zerfalls ^{3}H $\rightarrow$ ^{3}He + e$^-$ + $\bar{\nu}_e$ nahe dem kinematischen Endpunkt von 18.6 keV. Mit einer fensterlosen, molekularen, gasförmigen Tritiumquelle hoher Luminosität und einem hochauflösenden elektrostatischen Filter mit bisher unerreichter Energieauflösung ΔE = 1 eV, wird KATRIN eine modellunabhängige Bestimmung der Neutrinomasse mit einer erwarteten Sensitivität von 0.2 eV (90 % CL) ermöglichen. Für eine derart präzise Massenbestimmung ist insbesondere die Stabilität der Quelle bezüglich ihrer β-Aktivität ein Schlüsselparameter, um die geplante Nachweisgrenze für den Wert der Neutrinomasse zu erreichen. Um die erforderliche Stabilität der Quelle auf 0,1 % nachzuweisen ist ein präzises Monitoring notwendig. Die Nachweisgenauigkeit eines Tritium-Bremsstrahlungsmonitors wird unter anderem durch das zu erwartende Untergrundsignal limitiert. Untergrund entsteht durch Permeation von Tritium durch das Bremsstrahlung erzeugende Element (Be Fenster mit Au) sowie durch Adsorption von Tritium auf Gold- und Edelstahloberflächen. Die prinzipielle Machbarkeit eines Bremsstrahlungsmonitors für Tritium und die Höhe des Untergrundbeitrags zum Messsignal soll mithilfe des Testaufbaus TriReX (Tritium Rearsection Experiment) am Tritiumlabor Karlsruhe (TLK) gezeigt werden. Dieser Vortrag stellt den Aufbau und die ersten Resultate vor.

VA 3.2 Mon 14:20 HSZ 101

Kompatibilitätsexperimente von Turbomolekularpumpen mit Tritiumgas — •Florian Priester — Für die KATRIN Kollaboration, KIT, ITEP-TLK, Karlsruhe, Deutschland

Das KArlsruher TRItium Neutrino-Experiment KATRIN untersucht spektroskopisch das Elektronenspektrum des Tritium β-Zerfalls ^{3}H $\rightarrow$ ^{3}He + e$^-$ + $\bar{\nu}_e$ nahe dem kinematischen Endpunkt von 18.6 keV. Mit einer fensterlosen, molekularen, gasförmigen Tritiumquelle hoher Luminosität und einem hochauflösenden elektrostatischen Filter mit bisher unerreichter Energieauflösung ΔE = 1 eV, wird KATRIN eine modellunabhängige Bestimmung der Neutrinomasse mit einer erwarteten Sensitivität von 0.2 eV (90 % CL) ermöglichen. Für eine derart präzise Massenbestimmung ist insbesondere die Stabilität der Quelle bezüglich ihrer β-Aktivität ein Schlüsselparameter, um die geplante Nachweisgrenze für den Wert der Neutrinomasse zu erreichen. Um die erforderliche Stabilität der Quelle auf 0,1 % zu gewährleisten ist eine stabile Tritiumeinspeisung in die Quelle sowie ein aktives Pumpen erforderlich. Dieses erfolgt mit leistungsstarken Turbomolekularpumpen. Um die Tritiumverträglichkeit dieser zu überprüfen wurde am Tritiumlabor Karlsruhe das Testexperiment TriTOP (Tritium Test Of Pumps) aufgebaut und wird derzeit betrieben. Dieser Vortrag zeigt den Aufbau sowie die ersten Resultate dieses Testexperimentes. Gefördert vom BMBF unter Förderkennzeichen 05A08VK2 und dem Sonderforschungsbereich Transregio 27 "Neutrinos and Beyond".

VA 3.3 Mon 14:40 HSZ 101

Rotor temperature of turbo-molecular pumps in magnetic fields — •Joachim Wolf, Robin Grössle, Norbert Kernert, and Sebastian Riegel — KIT - IK/IEKP, Postfach 3640, 76021 Karlsruhe

The KATRIN neutrino experiment operates about 20 turbo-molecular pumps (TMP) in the vicinity of super-conducting magnets, pumping out tritium gas from the electron beam-line of the experiment. In a dedicated test setup with Helmholtz coils systematic studies have been conducted, investigating the rotor temperature and stability of operation of TMPs (Leybold MAG-W 2800 and MAG-W 2200) at full speed as a function of gas load, magnetic field strength and direction of the field. The temperature of the magnetically levitated moving rotor was measured in vacuum with an infra-red pyrometer. An empirical model has been developed, describing quantitatively the temporal progression of the rotor temperature as a function of gas flow and field strength of an external static magnetic field. The model requires 5 pump-specific parameters, characterising the heating effects of eddy currents and gas friction as well as cooling by radiation loss and convection. When designing a vacuum system with TMPs in a critical environment (e.g. magnetic beam-line, fusion reactor), the model can be used to predict the maximum temperature of the rotor, to ensure a save operation of the pump. The model has been applied for simulating strong, pulsed magnetic fields as they occur at nuclear fusion experiments (JET) and for TMPs in the tritium loop of the KATRIN experiment. KATRIN is supported by the German BMBF project 05A08VK2, DFG TR27 and HGF.

VA 3.4 Mon 15:00 HSZ 101

Vacuum-technical test experiment on the Differential Pumping Section DPS2-F of the KATRIN experiment — •Strahinja Lukic — Karlsruher Institut für Technologie

As a part of the KATRIN Transport System, the Diferential Pumping Section DPS2-F was designed to reduce the tritium gas flow at the output of the Windowless Gaseous Tritium Source (WGTS) by 5 orders of magnitude. The experimental test of the capability of DPS2-F to fulfill this task is described in this contribution. A dedicated vacuum-measurement setup was built and calibrated for the test. In addition, the same setup is used to establish the correction curve for the readings of the cold- and hot-cathode vacuum gauges in the DPS2-F beamline because of the effect of the stray magnetic fields of the DPS2-F on them.

VA 4: Vacuum Control and Monitoring

Time: Monday 15:20–16:00 Location: HSZ 101

VA 4.1 Mon 15:20 HSZ 101

Das Vakuumsteuersystem für den Frankfurt Niederenergiespeicherring (FLSR) — •Thomas Felix, Kurt Ernst Stiebing, Reinhard Dörner, Marco Völp, Steffen Enz, Annika Jung und Thomas Kruppi — Institut für Kernphysik der Goethe Universität Frankfurt, Max von Laue Straße 1, 60438 Frankfurt a.M.

Am Institut für Kernphysik an der Goethe Universität Frankfurt wird derzeit ein elektrostatischer Speicherring zur Untersuchung der Dynamik in Ion/Molekül Reaktionen bei Energien bis 50 keV aufgebaut (Frankfurt Low Energy Storage Ring - FLSR[1]). Ein Vakuum, deutlich besser als 10E-10 mbar wird angestrebt. Im Rahmen dieser Arbeit wurde das online Vakuumüberwachungsystem erstellt. Das Programm ist in der Programmierumgebung Labview umgesetzt und ermöglicht Diagnose, Protokollierung und Überwachung der Vakuummessgeräte und Pumpen. Es ist in das übergeordneten Steuerprogramms für den Betrieb des Speicherringes eingebettet.

[1] K.E. Stiebing et al. Nucl. Instr. and Meth. A 614 (2010) 10-16

VA 4.2 Mon 15:40 HSZ 101

Novel easy to handle method for vacuum systems control — •Dieter Müller — Oerlikon Leybold Vacuum GmbH, Köln, Germany

Vacuum systems consist of various pumps, gauges, and valves. For automation, control, and data collection these systems have to be integrated in a control that can either be based on a commercial software like 'Labview' or on a PLC. The time and effort for adaptation of hardware and programming is immense. Especially in experimental devices frequent changes of hardware are necessary and require time consuming new programming.

This paper presents a novel vacuum controller with an integrated pre-configured PLC. Components connected are automatically recognized. The initial wizard to configure the whole vacuum system including valves and process automation steps is passed in a few minutes. Later changes of hardware are either detected automatically or can be configured easily. Process data, system configuration, failure storage, and software updates are done via USB. Remote control is possible via

Ethernet or via WLAN and an app for smartphones. The controller supplies all power to all valves, active gauges, single phase roughing pumps plus 3-phase roughing pumps via an additional e-box.

VA 5: Gaede Prize talk (Philip Hofmann)

Time: Wednesday 14:00–14:45 Location: TRE Phy

Prize Talk VA 5.1 Wed 14:00 TRE Phy

Spin-split metallic surface states on semimetals and topological insulators — •Philip Hofmann — Department of Physics and Astronomy, Interdisciplinary Nanoscience Center Aarhus University, 8000 Århus C, Denmark

The surfaces of Bi, Sb and the so-called topological insulators (TIs) all share the property that their electronic structure is metallic, in sharp contrast to the bulk which is either semimetallic (Bi, Sb) or semiconducting (TI). The main reason for the existence of the metallic surface states is not bond-breaking but the loss of inversion symmetry at the surface, combined with a strong spin-orbit interaction. The surface states are almost completely non-degenerate with respect to the electron's spin and this has interesting consequences for their electron dynamics. Indeed, the surface states on TIs are predicted to exhibit a number of novel and exotic physical phenomena and have potential applications in spintronics and quantum computing. In this talk I will review some basic properties of spin-split surface states, relate the findings on semimetal surfaces to topological considerations and discuss the similarities and differences of surface states on semimetals and topological insulators.