DS 2: Layer Deposition

Time: Monday 9:30–10:45 Location: H14

DS 2.1 Mon 9:30 H14

Bidirectional Growth of Functional Oxides by Molecular Beam Epitaxy — •Nicolas Bonmassar[1], Georg Christiani[2], and Gennady Logvenov[2] — [1]University of Stuttgart, 70569 Stuttgart, Germany — [2]Max Planck Institute for Solid State Research, 70569 Stuttgart, Germany

Here I present some recent results on the use of offcut substrates by enabling atomic precision layer-by-layer growth in both in-plane and out-of-plane directions. This is achieved by in situ monitoring of the oscillations of the reflected high-energy electron diffraction (RHEED) patterns. The potential of this method is demonstrated using a bidirectionally grown superlattice of alternating $LaMnO_3$ and $SrMnO_3$ layers, showing interfacial ferromagnetism. This superlattice serves as a model system to showcase the method's versatility through detailed structural and functional characterization by using various scanning transmission electron microscopy techniques, sheet resistance measurements, and magnetometry. Next, the approach is applied to the growth of superconducting $La_{1.84}Sr_{0.16}CuO_4$ thin films grown in ozone atmosphere on various offcut substrates, where the anisotropic critical current is found to arise from two distinct mechanisms induced by the substrate geometry.

Furthermore, I will present the issues we faced when we first started this project and how we had overcome well-known problems like the loss over the in situ RHEED oscillations, terrace broadening, step bunching, 3D defect formation and the concomitant loss of functionalities like superconductivity.

DS 2.2 Mon 9:45 H14

Enabling vacuum process monitoring with time-of-flight spectroscopy — •Marco John, Kristian Kirsch, Andreas Trützschler, Christoph Bartlitz, Marcel Herrmann, and Klaus Bergner — VACOM Vakuum Komponenten & Messtechnik GmbH, Großlöbichau, Germany

A crucial aspect to manage industrial vacuum processes is the importance of fast in-situ monitoring and control of process parameters such as pressure and residual gas composition. Improving process control in this way minimizes production errors, avoids damage to process equipment and ensures longer operating times. The capabilities of hot cathodes and quadrupole mass spectrometers are limited for this complex task, as they can only measure either the total pressure or the gas composition. One answer to this challenge is our novel ion source NOVION*, which combines the well-known technology of time-of-flight spectroscopy with our patented ion trap to an industrially available gas analyzing application.

In this talk we present the fundamental physical principles of the novel ion source and explain the compact combination of time-of-flight spectroscopy with our own patented ion trap. We discuss the advantages and limits in different applications as well as best practices in the field and show the capability to push the principle to its limits at high pressures without compromising the performance or lifetime of the filaments.

DS 2.3 Mon 10:00 H14

Selective Area Atomic Layer Deposition via Photoexcitation — •Paul Butler[1,2], Stefan A. Maier[3], and Ian D. Sharp[1,2] — [1]Walter Schottky Institut, Technische Universität München, 85748, Garching, Germany — [2]Physics Department, TUM School of Natural Science, Technical Universität München, 85748, Garching, Germany — [3]School of Physics and Astronomy, Monash University, 3800, Melbourne, Australia

While atomic layer deposition (ALD) is a powerful technique for uniformly coating complex surfaces with thin films, achieving lateral control of ALD layers remains a primary challenge. In this work, we examine a selective-area ALD (S-ALD) process via photoexcitation of the growth surface. We demonstrate that optical laser excitation enhances ALD-growth of TiO_2 films on gold surfaces deposited onto Si and SiO_2. These surfaces were exposed to titanium isopropoxide (TTIP) and ozone as reactants for the ALD process, during which some of the samples were exposed to laser illumination. In-situ ellipsometry was used to monitor the growth rate of the TiO_2 films during ALD, and ex-situ ellipsometry was used to map the height profile of the resulting TiO_2 films deposited. The results show intensity-dependent enhanced growth on surfaces that were excited with laser illumination. We also show that a shadow mask can be used to make patterned depositions.

DS 2.4 Mon 10:15 H14

Enabling FAIR Data Practices in MBE Growth and Characterization — •Andrea Albino[1], Hampus Näsström[1], Sarthak Kapoor[1], Altuğ Yildirim[2], Oliver Bierwagen[2], Martin Albrecht[3], and Sebastian Brückner[1,3] — [1]Department of Physics, Humboldt-Universität zu Berlin, Berlin, Germany — [2]Paul-Drude-Institut für Festkörperelektronik, Leibniz-Institut im Forschungsverbund Berlin e.V., Berlin, Germany — [3]Leibniz-Institut für Kristallzüchtung, Berlin, Germany

Data-driven materials science is transforming materials design by moving beyond traditional trial-and-error methods. Molecular beam epitaxy (MBE) experiments highlight the challenge of navigating complex parameter spaces [1], often exceeding human cognitive limits, particularly when integrating diverse datasets. This complexity is compounded by the absence of standardized models for capturing detailed experimental workflows and instrument diversity. Addressing these issues requires metadata aligned with FAIR (Findable, Accessible, Interoperable, Reusable) principles [2].

Within the NOMAD ecosystem (nomad-lab.eu) [3], we digitize the data lifecycle for MBE growth, including in-situ and ex-situ characterization. Key tools, like Electronic Laboratory Notebooks (ELNs), systematically document growth procedures, enabling streamlined data management and AI-driven analytics to optimize MBE processes.

[1] O. Bierwagen et al., J. Phys. Condens. Matter 28, 22 (2016) [2] M. Wilkinson et al., Sci. Data 3, 160018 (2016) [3] M. Scheidgen et al., J. Open Source Software 8, 5388 (2023)

DS 2.5 Mon 10:30 H14

Role of point defects on the superconducting transition temperature in NbTIN thin films with positron annihilation spectroscopy — •Sebastian Klug[1], Maik Butterling[1], Maciej Oskar Liedke[1], Eric Hirschmann[1], Andreas Wagner[1], Bharath Reddy Lakki Reddy Venkata[2], Aleksandr Zubtsovskii[2], and Xin Jiang[2] — [1]Institute of Radiation Physics, HZDR, Germany — [2]Chair of Surface and Materials Technology, University of Siegen, Germany

Positron annihilation spectroscopy (PAS) is a non-destructive method for studying point defects in materials with high sensitivity. It can sense defect densities in the range of 10^{15} to $10^{19} cm^{-3}$. The time for positrons to annihilate with electrons depends on the local electron density. Therefore, positrons can be trapped in neutral and negatively charged open-volume defects. Positrons are implanted into the studied material with a defined implantation energy. Changing of this energy allows for depth-resolved characterization. The user facility ELBE of HZDR provides the two main PAS techniques Doppler broadening spectroscopy (DBS) and positron annihilation lifetime spectroscopy (PALS) which allows for evaluation of the atomic environment of defects as well as defect size and density.

In this contribution the most recent results of magnetron sputtered NbTiN thin films as promising candidate for improving the characteristics of superconducting radio-frequency cavities (SRF cavities) will be discussed. The correlation between defect size and their concentration and the superconducting transition temperature will be highlighted.