P 5: Low Pressure Plasmas I

Time: Tuesday 11:00–12:30 Location: KH 02.016

Invited Talk P 5.1 Tue 11:00 KH 02.016

Nanoparticles prepared by sputter-driven gas aggregation — •Andrey Shukurov — Charles University, Faculty of Mathematics and Physics, Department of Macromolecular Physics, Prague, Czech Republic

Sputter-driven gas aggregation, first pioneered by the Freiburg group in the 1990s, has become a well-established and versatile method for synthesizing metal nanoparticles (NPs) through the condensation of atomic metal vapors in a cold inert gas. While planar magnetrons have traditionally been used for this process, the gradual evolution of their erosion tracks imposes limitations on process stability and controllability. Cylindrical magnetrons offer an effective way to overcome these constraints and significantly extend target lifetime. However, despite their widespread use in thin-film deposition, cylindrical magnetrons have not yet been adapted for gas-phase nanoparticle synthesis. In this contribution, we demonstrate the use of dc planar and cylindrical magnetrons for the gas-phase production of metal NPs, including hybrid bimetal nanoparticles with complex morphologies such as core@shell and Janus structures. We further present reactive sputtering in Ar/N2 mixtures, which enables the synthesis of metal nitride (MeN) nanoparticles, where Me = Ti, Zr, Hf, Cu, or Fe. By systematically varying gas composition, pressure, and discharge current, we obtain nanoparticles with tunable size distributions and chemical compositions. The resulting materials show strong potential for applications in refractory plasmonics, solar-light harvesting, and electrochemical CO2 reduction. Representative results will be presented and discussed.

P 5.2 Tue 11:30 KH 02.016

Influence of discharge parameters on the synthesis and properties of nanoparticles in reactive plasmas — •Alexander Schmitz, Andreas Petersen, and Franko Greiner — Institute of Experimental and Applied Physics, Kiel University, Germany

Reactive plasma can be an attractive source for sub-micron particles of several 100 nm size. Such particles are be a candidate for pharmaceutical carriers, catalytic or functional material. The influence of the discharge parameters on the accretion growth process and the nanoparticle properties especially still pose open questions. Their precise determination is not only of importance for fundamental research on particle dynamics and electron depletion processes, but also for potential technical applications.

Modern *in-situ* diagnostics based on light scattering like full-Stokes imaging polarimetry offer valuable insight into the particle characteristics. It is a door opener for accessible computer vision and precise scattering modeling to access particle properties. We present a first study on the tunability of nanoparticle properties with regard to the particle size distributions, complex refractive index and their spatial dynamics.

P 5.3 Tue 11:45 KH 02.016

Calorimetric and electrostatic probe diagnostics of a gas aggregation source plasma — •Caroline Adam[1], Viktor Schneider[1], Jessica Niemann[1], Daniil Nikitin[2], Jan Hanuš[2], Ronaldo Katuta[2], Iqra Wahid[2], Veronika Červenková[2], Andrey Shukurov[2], Hynek Biederman[2], and Holger Kersten[1,3] — [1]Institute of Experimental and Applied Physics, Kiel University, Kiel, Germany — [2]Faculty of Mathematics and Physics, Department of Macromolecular Physics, Charles University, Prague, Czech Republic — [3]Kiel Nano, Surface and Interface Science KiNSIS, Kiel University, Kiel, Germany

Gas aggregation cluster sources (GAS) have been emerging as a key technology for the production of clusters and nanoparticles (NPs) of precise size and composition. The resulting NP properties are significantly affected by the thermal balance during their growth in the aggregation zone. In this study, the characteristics of a novel controllable GAS setup are investigated, using a post (cylindrical) magnetron with a rotating magnetic circuit [1] equipped with a copper target in Ar and/or N2 atmosphere, respectively. Energy fluxes are quantified by calorimetric measurements using passive thermal probes (PTP), while the plasma parameters are assessed by Langmuir probes. These quantities are critical to develop a comprehensive understanding of the correlation between (external) process parameters (e.g., current, voltage, continuous or pulsing, gas pressure) and (internal) plasma parameters and their correlation with NP growth, transport and microstructure.
[1] D. Nikitin et al., Plasma Processes Polym. 18 (2021).

P 5.4 Tue 12:00 KH 02.016

Non-adiabatic electron energization mechanism in plasmas with a magnetron configuration — •Lukas Vogelhuber[1], Kevin Köhn[1], Dennis Krüger[1], Jens Kallähn[1], Yulia Sharova[1], Liang Xu[2], Ralf Peter Brinkmann[1], and Denis Eremin[1] — [1]Institute of Theoretical Electrical Engineering, Ruhr University Bochum, Universitätsstrasse 150, D-44801 Bochum, Germany — [2]School of Physical Science and Technology, Soochow University, Suzhou 215006, China

Partially magnetized plasma discharges in $E \times B$ configurations are versatile tools, with applications ranging from Hall-effect thrusters for space propulsion to high-power impulse magnetron sputtering (HiPIMS) for thin-film deposition. In these configurations, structures known as spokes can form as potential humps moving in the $\pm E \times B$ direction, and influence electron dynamics. Electrons confined in the racetrack region are typically considered to be magnetized, with their magnetic moment serving as an indicator of the degree of confinement; if the magnetic moment is conserved along the trajectory, the energization is adiabatic. However, various processes can disrupt this conservation, including collisions, field interactions, and resonant particle motion, leading to non-adiabatic energy gain by electrons. In this work, this phenomenon is studied to gain a deeper understanding of the collisionless energization of electrons at potential humps in magnetized plasmas.

P 5.5 Tue 12:15 KH 02.016

Interaction of fast particle agglomerates with a dusty plasma — •Daniel Maier, Christina Knapek, André Melzer, Daniel Mohr, and Stefan Schütt — Institute of Physics, University of Greifswald, Germany

Fast objects moving through a dispersive medium can interact in various ways and create a variety of phenomena (e.g. Mach cones or shocks). The investigation of this interaction has been a topic of research for long times.

Interactions of a dusty plasma under microgravity disturbed by fast particle agglomerates were observed in experiments using the "Zyflex" chamber. A cloud of micron sized particles in a low temperature plasma was disturbed by fast particle agglomerates that were unintentionally accelerated to high velocities during the experiments. This disturbance can lead to dust-free cavities in the region of the agglomerates with varying shape and size dependent on the velocity of the agglomerate and its moving direction in relation to the plane of the illuminating laser. Using a stereoscopic camera set-up consisting of four high-speed cameras with a resolution of 2.1 MP at a frame rate of 200 fps it is possible to calculate the spatial position of the dust particles and their motion during the interaction with the fast agglomerates in three dimensions.

In this contribution observations of such interactions will be shown focusing on the velocities and density of the surrounding dust particles as well as the spatiotemporal characteristics of the the dust-free cavity.

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