P 15: Laser Plasmas II/Low Pressure Plasmas and their Applications II

Time: Thursday 14:00–15:30 Location: CHE/0089

Invited Talk P 15.1 Thu 14:00 CHE/0089

Tumor irradiation in mice with a laser-accelerated proton beam — •Florian Kroll[1], Florian-Emanuel Brack[1], Elke Beyreuther[1,2], Thomas Cowan[1,3], Leonhard Karsch[1,2], Josefine Metzkes-Ng[1], Jörg Pawelke[1,2], Marvin Reimold[1,3], Ulrich Schramm[1,3], Tim Ziegler[1,3], and Karl Zeil[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]OncoRay - National Center for Radiation Research in Oncology, Dresden, Germany — [3]Technische Universität Dresden, Dresden, Germany

We report on establishing a laser-plasma-based proton research platform for user-specific small animal radiobiology studies. The Draco PW laser at Helmholtz-Zentrum Dresden-Rossendorf drives the laser-plasma accelerator (LPA). We discuss the findings that allowed us to operate our LPA proton source with unprecedented stability and long-term reliability, featuring proton energies regularly exceeding 60 MeV.

These capabilities allowed us to conduct the first radiobiological in vivo study using an LPA proton source. The pilot study was performed on human tumors in a mouse model, showing the concerted preparation of mice and laser accelerator, the dose-controlled, tumor-conform irradiation using the LPA as well as a clinical reference proton source, and the radiobiological evaluation of irradiated and unirradiated mice for radiation-induced tumor growth delay. The prescribed homogeneous dose was precisely delivered at the laser-driven source.

The presented results prove that LPA proton sources have reached a new level of applicability and now enable systematic radiobiological studies within an unprecedented range of beam parameters.

P 15.2 Thu 14:30 CHE/0089

Comparison between THz absorption spectroscopy and ps-TALIF measurements — •Jente R. Wubs[1], Laurent Invernizzi[2], Kristaq Gazeli[2], Guillaume Lombardi[2], Uwe Macherius[1], Klaus-Dieter Weltmann[1], and Jean-Pierre H. van Helden[1] — [1]Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany — [2]Laboratoire des Sciences des Procédés et des Matériaux (LSPM), CNRS, Université Sorbonne Paris Nord, Villetaneuse, France

Terahertz (THz) absorption spectroscopy with quantum cascade lasers has recently been developed and implemented as a new diagnostic technique for investigating atomic oxygen densities in plasmas. It is based on the detection of the $^3P_1 \leftarrow {}^3P_2$ fine structure transition at approximately 4.75 THz. This allows for direct measurements (i.e. no calibration procedure required) of absolute ground-state atomic oxygen densities. A possible way to validate this method is by a comparison with two-photon absorption laser-induced fluorescence (TALIF), as this is currently the most established method for measuring atomic oxygen densities. TALIF measurements were done in this case with a picosecond (ps) laser system and using a streak camera for detection. Both ps-TALIF measurements and THz absorption spectroscopy were performed on the same low-pressure capacitively-coupled radio frequency plasma generated in pure oxygen, for a variation of the applied power (20–100 W) and gas pressure (0.7–1.3 mbar). A comparison between resulting atomic oxygen densities as obtained with the two different diagnostics is presented in this contribution.

P 15.3 Thu 14:45 CHE/0089

Characterization of the ion angle distribution function in low-pressure plasmas using a microelectromechanical system — •Marcel Melzer[1], Katja Meinel[1], Chris Stoeckel[1,2], Torben Hemke[3], Thomas Mussenbrock[3], and Sven Zimmermann[1,2] — [1]Center for Microtechnologies, Chemnitz University of Technology, Chemnitz, Germany — [2]Fraunhofer Institute for Electronic Nano Systems ENAS, Chemnitz, Germany — [3]Chair Electrical Engineering and Plasma Technology, Faculty of Electrical Engineering and Informationtechnology, Ruhr-University Bochum, Germany

It has been demonstrated for the first time that a microelectromechanical system (MEMS) can be used to characterize the ion angle distribution function (IADF) of a low-pressure plasma. The MEMS is piezoelectrically actuated. The piezoelectric AlN is used both to tilt a 30 μm thick silicon plate as well as to monitor the tilt angle. Holes with a diameter of 2 μm were etched into the tilting plate. These high aspect ratio holes allow selection of ion incidence angles depending on the tilt angle of the MEMS. Below the MEMS, the ions are detected by a metal electrode. A numerical method is presented to determine the ion angle distribution function based on the measured data for the resonant operation of the MEMS.

P 15.4 Thu 15:00 CHE/0089

Collisional radiative modelling for molecular hydrogen plasmas applying MCCC cross sections — •Richard Christian Bergmayr, Dirk Wünderlich, and Ursel Fantz — Max-Planck-Institut für Plasmaphysik, Garching, Germany

Molecular hydrogen (H_2) occurs in a variety of plasmas (e.g. negative ion source and fusion divertor plasmas). Collisional radiative (CR) models enable the characterization of these plasmas not only by their plasma parameters in combination with emission spectroscopy, but also to evaluate effective reaction rates (e.g. for molecular assisted recombination (MAR), a mechanism that may contribute to the detachment in divertors). CR models balance (de-)populating mechanisms of excited states in terms of coupled rate equations. Recent studies using a CR model for the triplet system of H_2 have shown that applying electron impact excitation cross sections calculated by the molecular convergent close-coupling (MCCC) method in the adiabatic-nuclei formulation show an improved agreement with measurements in low-pressure plasmas compared to models based on previously available cross sections. In this work a CR model for the electronic states of the singlet system of H_2 applying MCCC cross sections is presented showing likewise as the triplet model better agreement with measurements than previous models. Furthermore, the models for the singlet and triplet system are coupled. Thereby it is possible to estimate also the influence of (optically forbidden) spin-mixing processes. In a next step this knowledge can be used to create a (ro-)vibrationally resolved model for H_2, as (ro-)vibrational excitation is expected to enhance MAR.

P 15.5 Thu 15:15 CHE/0089

First-principles simulation of optical emission spectra for low-pressure argon plasmas and its experimental validation — Fatima Jenina Arellano[1], Márton Gyulai[2,3], Zoltán Donkó[1,3], Peter Hartmann[3], •Tsanko Vaskov Tsankov[4], Uwe Czarnetzki[4], and Satoshi Hamaguchi[1] — [1]Center for Atomic and Molecular Technologies, Osaka University, Osaka, Japan — [2]Eötvös Loránd University, Budapest, Hungary — [3]Institute for Solid State Physics and Optics, Wigner Research Centre for Physics, Budapest, Hungary — [4]Ruhr University Bochum, Faculty of Physics and Astronomy, Experimental Physics V, Germany

The emission intensity of various spectral lines are often used for the experimental characterization of low-temperature plasmas. However, the interpretation of the spectra requires knowledge of the electron distribution function and the population-depopulation kinetics of the emitting states. To investigate these relations and to test the suitability of numerical models for relating the measured emission spectra to the underlying plasma parameters, we perform here first-principle simulations for low-pressure radio-frequency driven capacitively-coupled argon plasmas via one-dimensional particle-in-cell/Monte Carlo collision (PIC/MCC) code coupled to a global collisional-radiative model. The model provides the emission intensities of various atomic lines which are compared with experimental data. The comparison shows good agreement for pressures up to about 20 Pa and increasingly notable deviations at higher pressures. Possible explanations for the deviations are discussed.