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Temperature diagnostics of a non-thermal plasma jet at atmospheric pressure[1]

JAN SCHÄFER, Leibniz Institute for Plasma Science and Technology Greifswald

The study reflects the concept of the temperature as a physical quantity resulting from the second thermodynamic law. The reliability of different approaches of the temperature diagnostics of open non-equilibrium systems is discussed using examples of low temperature atmospheric pressure discharges. The focus of this work is a miniaturized non-thermal atmospheric pressure plasma jet for local surface treatment at ambient atmosphere [1]. The micro-discharge is driven with a capacitively coupled radio frequency electric field at 27.12 MHz and fed with argon at rates of about 1 slm through the capillary with an inner diameter of 4 mm. The discharge consists of several contracted filaments with diameter around 300 μm which are rotating azimuthally in the capillary in a self-organized manner. While the measured temperatures of the filament core exceed 700 K, the heat impact on a target below the plasma jet remains limited leading to target temperatures below 400 K. Different kinds of temperatures and energy transport processes are proposed and experimentally investigated. Nevertheless, a reliable and detailed temperature diagnostics is a challenge. We report on a novel diagnostics approach for the spatially and temporally resolved measurement of the gas temperature based on the optical properties of the plasma [2]. Laser Schlieren Deflectometry is adapted to explore temperature profiles of filaments and their behaviour. In parallel, the method demonstrates a fundamental Fermat's principle of minimal energy. Information acquired with this method plays an important role for the optimization of local thin film deposition and surface functionalization by means of the atmospheric pressure plasma jet.

[1] Schäfer et al., Eur. Phys. J. D 60, 531 (2010).
[2] Schäfer et al., Rev. Sci. Instrum. 83, 103506 (2012).

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