Measurements of densities of gas constituents in a micro/nano-scale discharge device with a large wall probe

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An approach leading to the development of gas analytical detectors has been previously reported [1,2]. This approach is based on the use of a large electric wall probe to measure fine structures associated with atomic and molecular plasma processes at the high-energy portion of the electron energy distribution function (EEDF) in the near-cathode plasma. The large-area wall probe provides increased sensitivity of the gas detector. However, the additional potentials that are necessary to apply to the probe during the measurements can significantly change the properties of the entire plasma in the discharge [3], thus altering the EEDF, which the probe is attempting to measure. As a result, each measured EEDF can be associated with a different plasma for different energies (probe potentials). This is not an issue, though, as the exact knowledge of the undisturbed EEDF is not really important for measurements of densities of gas constituents. The result of the measurements can be corrected by calibrating with known gas mixtures. Even though the ratios of the high-energy electron features in the EEDF change with probe potential, the presence of a specific target gas component can still be monitored from the measured EEDF.

In this work, a short (without positive column) dc micro/nano-scale discharge with cold cathode and conducting walls was used in experiments at atmospheric gas pressures [1]. For the investigated conditions, the plasma is collisional and one might expect that maxima corresponding to arising energetic electrons are proportional to the first derivative of electron current with respect to the probe potentials (collisional probe theory) [4]. However, it is experimentally shown that in some devices the maxima are proportional to the second derivative of electron current with respect to the probe potentials (as in collisionless theory [4]). The reason for this discrepancy is unknown and still should be investigated. Measurements have been conducted in Helium-Argon gas mixtures with content of Argon from 0.002 to 5% and calibration of the device has been demonstrated.

References

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