A miniaturized plasma as a detector for gas chromatography

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Abstract

The dielectric barrier discharge is presented as a powerful micro-excitation source for analytical spectrometry. The dielectric barrier discharge is characterized by small size, low electric power (< 1 Watt), low mean gas temperature (about 600 K) and excellent dissociation capability for molecular species, such as CCl_2F_2, $CClF_3$ and $CHClF_2$.

Diode laser atomic absorption spectrometry (DLAAS) measurements monitoring the Cl 837 nm absorption line in the dielectric barrier discharge (DBD) result in detection limits of 400 ppt and 5 ppb of CCl_2F_2 in helium and in argon, respectively. These values are comparable with those obtained in traditional larger plasma sources. The low average gas temperature and the absence of sputtering leads to plasma chip lifetime of more than 500 h.

DLAAS measurements were also performed to determine the plasma parameters with spatial and temporal resolution. It could be shown that the electron density reaches 10^{15} cm^{-3} in a small volume close to the temporary cathode while the gas temperature peaks at 1000 K in that region. In other areas and between the discharge cycles the electron density is low that it cannot be measured taking into account the experimental uncertainty. Here, the gas temperature is near room temperature. The gas temperature was derived from the Doppler line widths.

The high concentration of power density (about 0.1 kW/cm^3) in a small constricted volume makes the dielectric barrier discharge suitable for the coupling with a gas chromatograph. The capability of the dielectric barrier discharge as an element-selective diode laser absorption detector for gas chromatography was investigated. Detection limits of halogenated and sulfured hydrocarbons from the low to the high pg/s-range were obtained, depending on the element measured. Furthermore, the effect of doping gas (oxygen) and make-up gas (argon, helium) on the chromatograms was studied.