Diagnostics to study the vibrational kinetics of CO_2 in non-thermal plasma

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During the presentation I will discuss the development of three diagnostics to increase our current level of understanding of the vibrational kinetics within CO_2 discharges, with the intention to ultimately contribute to a controlled and efficient CO_2-dissociation process. The diagnostic techniques are (1) time resolved *in situ* Fourier transform infrared (FTIR) spectroscopy, (2) spatiotemporally resolved *in situ* rotational Raman spectroscopy and (3) two-photon absorption laser induced fluorescence (TALIF).

With diagnostic (1) line-of-sight averaged transmittance spectra are recorded with a spectral resolution of 0.2 cm^{-1} and a temporal resolution of 10 µs to be able to track the evolution of different (pulsed) plasmas [1]. Additionally, an analysis algorithm was developed to be able to compute the transmittance through a non-thermal medium of CO_2, CO, and O_2. For diagnostic (2) a laser setup is built, employing a 100Hz Nd:YAG laser which is frequency doubled to 532 nm, and an algorithm is developed to measure and analyze spatiotemporally resolved pure rotational Raman spectra. Before Raman scattered light can be recorded, the intense Rayleigh scattered light has to be rejected which is done by implementing a volume Bragg grating (VBG) as an ultra-narrow-band notch filter (OD 3 to 4, 7 cm^{-1} full-width at half-maximum) [2]. With diagnostic (3) we focused on the time-resolved detection of CO, i.e. one of the products in the dissociation process of CO_2 by means of two-photon absorption laser induced fluorescence (TALIF). The two-photon transition that is used to excite CO is the ($X^1\Sigma^+ \rightarrow B^1\Sigma^+$)-transition. The 230 nm photons that are needed for the two-photon excitation are generated from a Nd:YAG pumped dye laser, operating on Coumarin-460 dye and doubled in a BBO crystal. The fluorescence after CO excitation is from the ($B^1\Sigma^+ \rightarrow A^1\Sigma^+$)-transition, i.e. between 450 and 750 nm, and is detected by means of a photomultiplier tube. The B-state is used for the TALIF measurements as this state has a rather long natural lifetime (22 ns), which allows for absolute density measurements under not too high-pressure conditions [3].

The parameters of interest that were acquired from the analysis of the data of the three diagnostics are: T_{rot}, the rotational temperature; T_3, the temperature of the asymmetric stretch vibration of CO_2; $T_{1,2}$, the combined temperature of the other two CO_2 vibrations; T_{CO}, the vibrational temperature of CO; the conversion of CO_2 to CO (i.e. the number densities of both molecules). The results provide ample experimental foundation to expand our knowledge on CO_2 vibrations and dissociation, especially through comparison with numerical models.

This work is partly supported by NWO, under project numbers 713.013.003 and 15325 and has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 813393.

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