GAS TEMPERATURE MEASUREMENTS IN A HIGH PRESSURE ARGON PULSED DIELECTRIC BARRIER DISCHARGE USING DIODE LASER ABSORPTION SPECTROSCOPY

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A tunable diode laser absorption spectroscopic technique has been used to quantify the high-pressure (p=100–500 Torr) scaling of gas temperature in an argon dielectric barrier discharge (DBD) excited using two different applied unipolar voltage pulses from 1.7-6.0 kV and <800 μJ/pulse maximum deposited energy. The diode laser tuning range was sufficient to capture both collision-broadened "wings" of the $1s_3$-$2p_2$ (772.42 nm) and $1s_5$-$2p_7$ (772.39 nm) transitions simultaneously in a single scan. The diagnostic technique is based upon Lindholm-Foley theory[1] which is particularly applicable for highly nonequilibrium discharge conditions in which the Lorentzian line shape dominates over the Doppler component. Along with the ideal gas law, Lindholm-Foley theory can be used to express both "shift" and "collision width" temperatures as $T_s=T_o(\beta_o p/\beta)^{10/7}$ and $T_c=T_o(2\gamma_o p/2\gamma)^{10/7}$, respectively, where T_o=300 K, β_o, and $2\gamma_o$ are the reduced shift and broadening coefficients for a specified transition. In order to use this method to measure small gas temperature changes, it is important to obtain accurate values of β_o and $2\gamma_o$ for each transition. Measurements of $2\gamma_o$ were not found in literature[2], while β_o was found to be systematically biased[2]. Estimates of these coefficients were performed using a self-consistent *in situ* cross-calibration incorporating both transitions, (i) low pressure measurements of $2\gamma_o$ and (ii) high pressure measurements of the absolute shifts and line widths. Low pressure (p=5-50 Torr) measurements gave $2\gamma_o(1s_3\text{-}2p_2)=22.8\pm1.0$ MHz/Torr and $2\gamma_o(1s_5\text{-}2p_7)=21.6\pm0.3$ MHz/Torr. Frequency shift measurements were performed by comparing absorption peaks obtained simultaneously from the DBD and a 1 Torr argon dc discharge. The 2γ measurements were obtained from Voigt profile fitting. Lindholm-Foley theory predicts that $\beta/2\gamma = \beta_o/2\gamma_o \approx -0.3627$. Our measurements indicate that $\beta_o/2\gamma_o=-0.333\pm0.025$ for both transitions so that within the specified uncertainties, $\beta_o(1s_3\text{-}2p_2)\approx-7.6\pm0.7$ MHz/Torr and $\beta_o(1s_5\text{-}2p_7)\approx-7.2\pm0.5$ MHz/Torr. Over the range of pressure and voltages, the measured gas temperature was nearly constant at 330±30 K.

1. N. Allard and J. Kielkopf, "The Effect of Neutral Nonresonant Collisions on Atomic Spectral Lines", Rev. Mod. Phys. **54**, No. 4, 1982, pp. 1103-1182.
2. P.S. Moussounda and P. Ranson, "Pressure Broadening of Argon Lines Emitted by a High-Pressure Microwave Discharge (Surfatron)", J. Phys. B: At. Mol. Phys. **20**, 1987, pp. 946-961.