TIME-RESOLVED POPULATIONS OF $N_2(A^3\Sigma_u{}^+,v)$ IN NANOSECOND PULSE DISCHARGE PLASMAS

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Absolute time-resolved populations of $N_2(A^3\Sigma_u{}^+)$ excited electronic state generated in a repetitive ns pulse discharge in nitrogen have been measured by Cavity Ring Down Spectroscopy (CRDS) and Tunable Diode Laser Spectroscopy (TDLAS). CRDS measurements of $N_2(A^3\Sigma_u{}^+,v=0\text{-}2)$ populations are made in the discharge afterglow at a pressures of 10-40 Torr. The data reduction procedure takes into account the linewidth of the pulsed laser source, comparable with the absorption linewidth and resulting in a non-single exponential ring down decay. Peak $N_2(A^3\Sigma_u{}^+,v=0,1)$ populations after a 10-pulse ns discharge burst are 1.5x10^{11} cm^{-3}. In the afterglow, these populations exhibit a relatively slow decay with the characteristic time of approximately 500 μs, most likely due to the quenching by the N2 molecules in the ground electronic state. TDLAS data have been taken at a higher pressure of 130 Torr. Absolute time-resolved $N_2(A^3\Sigma_u{}^+,v=0,1)$ number densities are measured during ns pulse discharge bursts up to 25 pulses long and in the afterglow, peaking at 5x10^{12} cm^{-3} and 3x10^{13} cm^{-3}. The results indicate that $N_2(A^3\Sigma_u{}^+)$ is generated after every discharge pulse on a 20-50 μs time scale, much longer compared to the discharge pulse duration, and decays between the pulses. The decay rate increases during the discharge burst. In the afterglow, $N_2(A^3\Sigma_u{}^+,v=0,1)$ populations decay significantly more rapidly compared to the low-pressure CRDS conditions, with the characteristic time of approximately 100 μs. The results demonstrate that both CRDS and TDLAS diagnostics can be used for time-resolved, absolute $N_2(A^3\Sigma_u{}^+)$ measurements in transient nonequilibrium plasmas and the afterglow, with the detection limit of $\approx 10^{10}$ cm^{-3}. The data obtained using these two diagnostics are complementary, since TDLAS measurements can be used at the conditions when the $N_2(A^3\Sigma_u{}^+)$ populations may be too high, or vary too rapidly for accurate CRDS measurements.