High Pressure NO PLIF

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Investigation of NO Detection Strategy

Detection of nitric oxide during combustion is of particular interest as NO is one of the most important combustion-generated pollutants. Engine effluent is a major source of NO, and this species influences atmospheric ozone depletion and smog formation. Drastic regulatory restrictions on NO are planned for the future. Laser-based diagnostics techniques are widely used to investigate improvements in practical combustion emissions. Laser-induced fluorescence (LIF) can provide instantaneous two-dimensional images of absolute concentration fields without influencing the combustion process. Laser-induced fluorescence (LIF) techniques using excitation in the A-X and D-X electronic systems have proven a reliable technique for two-dimensional imaging of nitric oxide concentrations in practical combustion systems.

However, at pressures above 10 atmospheres, attenuation of the excitation laser in the hot combustion gases and interference from molecular oxygen LIF cause significant problems for NO LIF. We have conducted spectroscopic point measurement investigation of different strategies for NO LIF excitation and detection from selected transitions in the A-X (0,0), (0,1), and (0,2) bands. Computer simulations along with actual spectral scans are being analyzed in the process. We have reported measurements in laminar premixed methane/air flames at pressures between 1 and 60 bar, and based on these results. The advantages and disadvantages inherent in each of these three excitation strategies have been identified.

Figure 1: High pressure burner

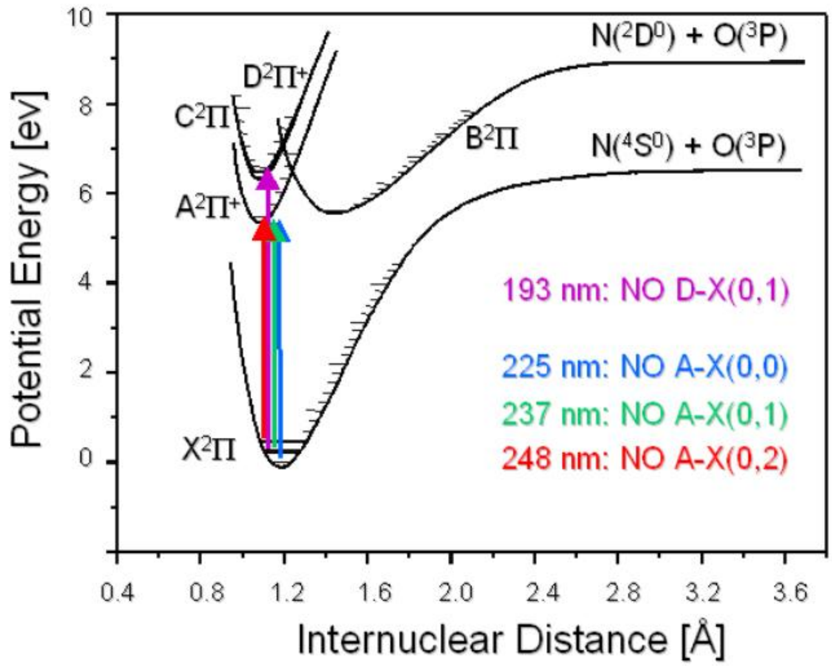

Figure 2: NO potential diagram for excitation scheme

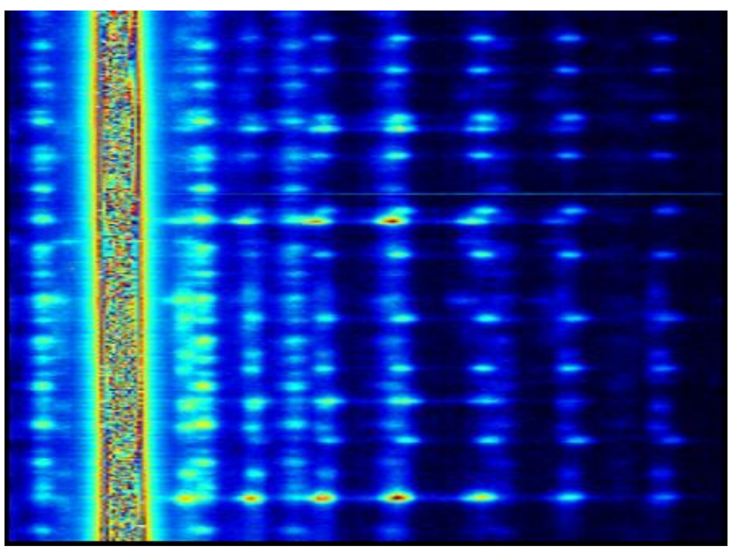

Figure 3: Excitation (vertical) and emission (horizontal) spectrum [40 bars]

Quantitative Temperature Fields at High Pressure (2-D PLIF of NO)

Through spectral line investigations A-X(0,0) P1(23.5), Q1+P21(14.5), Q2+R12(20.5) excitation feature at 226.03 nm, the A-X(0,1) Q1+P21(17.5), R1+Q21(11.5), P1(25.5) transition at 235.88 nm, and the A-X(0,2) O12 bandhead at 247.94 nm were verified to provide the best NO LIF/background ratio in the respective vibrational bands. These different strategies have different application potential due to their variations in spectroscopic detection regions and interference levels from other signals. Utilizing a combination of these strategies, quantitative thermometry is being investigated. The requirements are that the temperature fields must provide high accuracy, 2D temperature distributions, instantaneous measurements for turbulent flame applications, feasible in high pressure environments and being able to apply in fresh and burnt gases simultaneously.

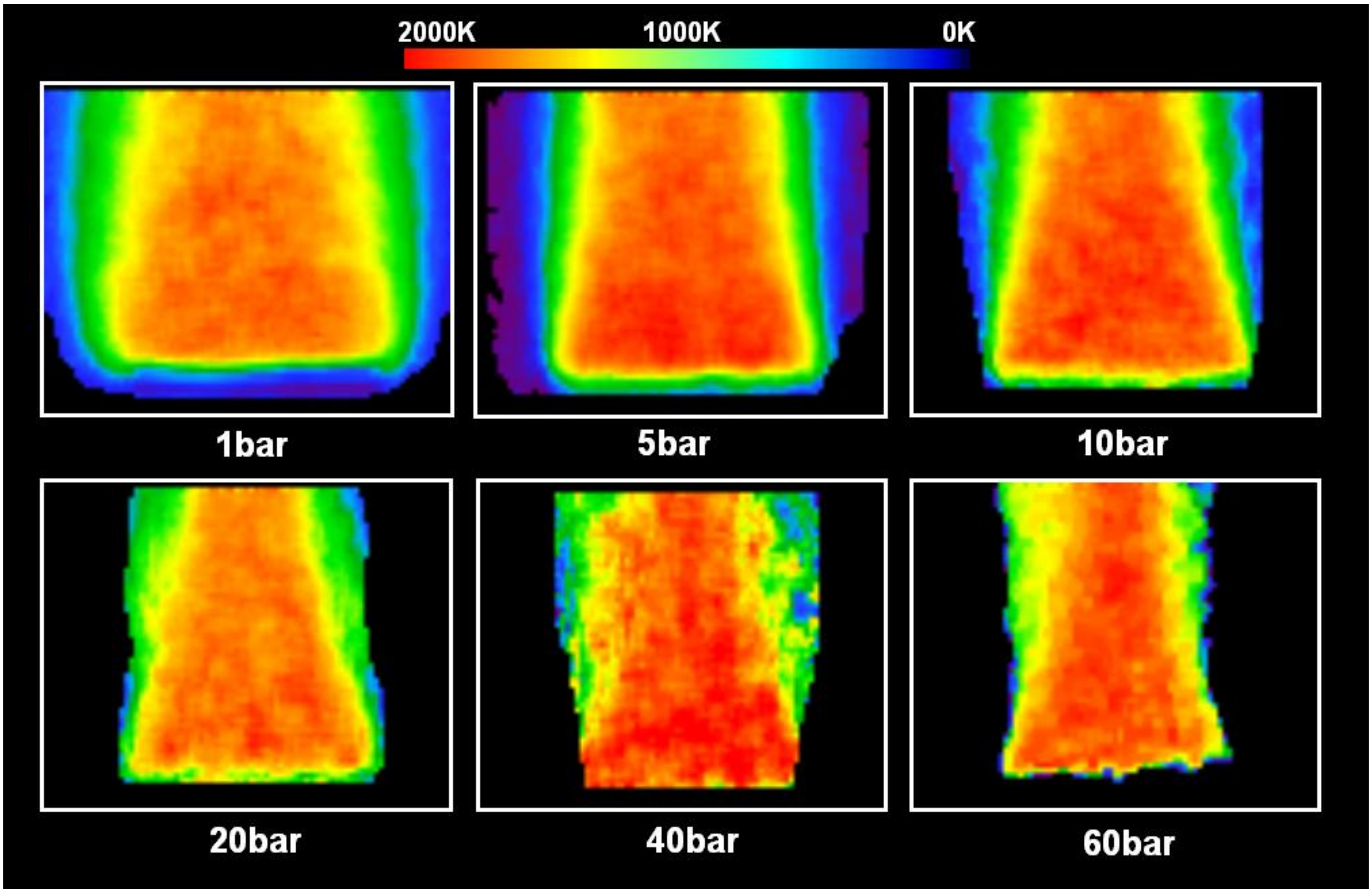

Figure 4: Temperature field Imaging using A-X(0,0) NO PLIF

Quantitative High Pressure NO Imaging

Quantitative imaging of NO concentration is important for many practical high-pressure combustion applications. In steady laminar flames multiple sequential laser-based measurements can be made to determine corrections to increase accuracy of the image; however, in practical combustors with turbulent flames not all required correction data can be obtained simultaneously on a single-shot basis. Quantitative investigation of the influence of various corrections on NO laser-induced fluorescence using detailed measurements in laminar methane/air flat flames at 1–60bar were carried out. This includes investigation of the influence of O2 interference, the dependence on local temperature, the influence of gas composition and the effect of laser and signal attenuation by UV light absorption. In practical devices, these attenuation effects may be a major source of errors. Understanding the dynamic range for each of these corrections provides guidance to the measurement errors in single shot images at high pressure.

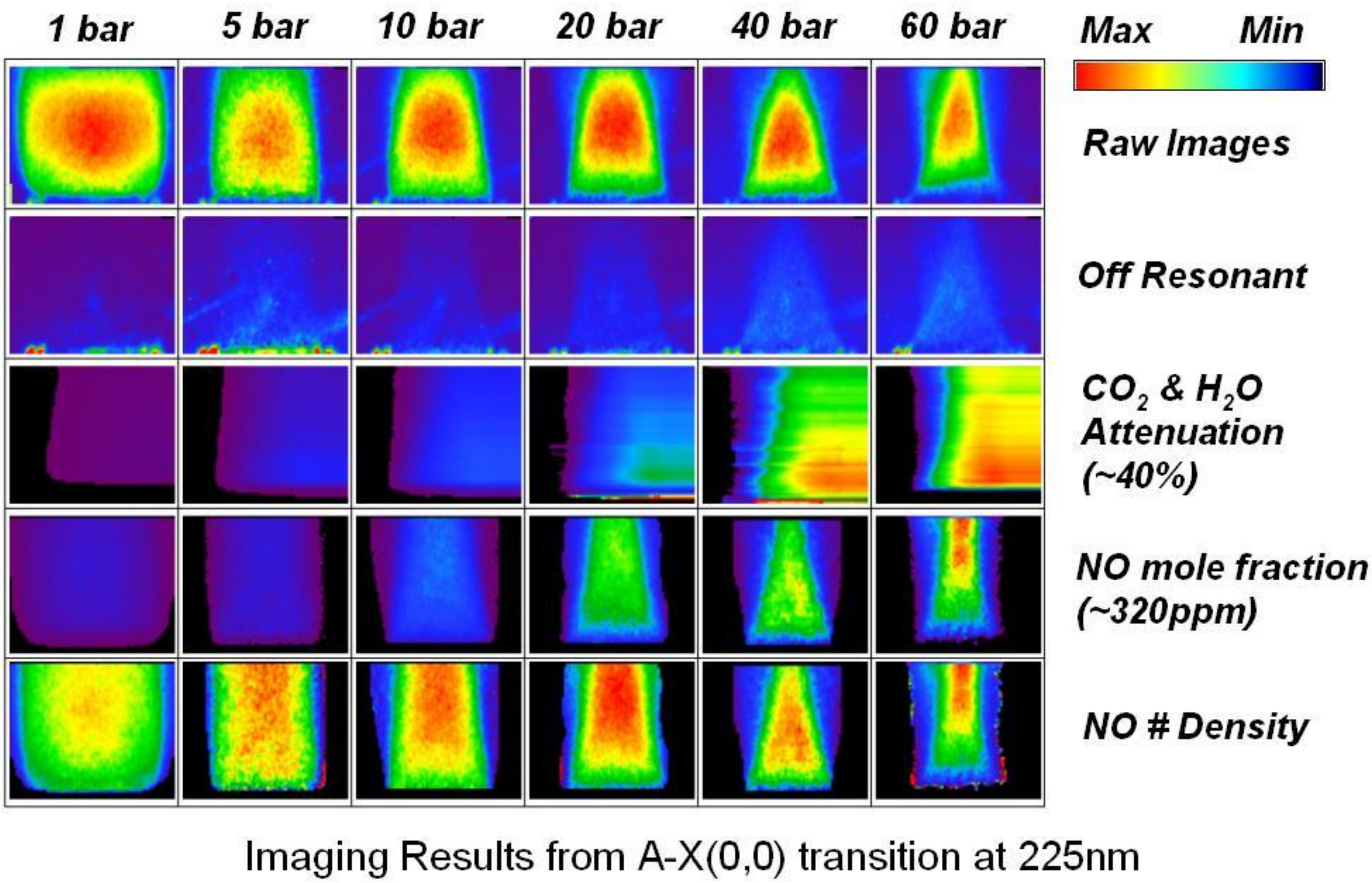

Figure 5: Quantitative NO-LIF imaging in high pressure flames

Practical Application

Ultimate goal of developing high pressure spectroscopic techniques is for application in actual practical combustors. Internal combustion engines, gas turbines and scram jet engines are just some of the applications. Apart from complications caused by pressure alone, practical combustors also commonly provide poor optical access, fluctuation of pressure and temperature, turbulence in the flow and interference from impurities and other hydrocarbons. Work is underway to develop a single shot high-pressure detection methods which will allow imaging in practical turbulent high pressure combustors.

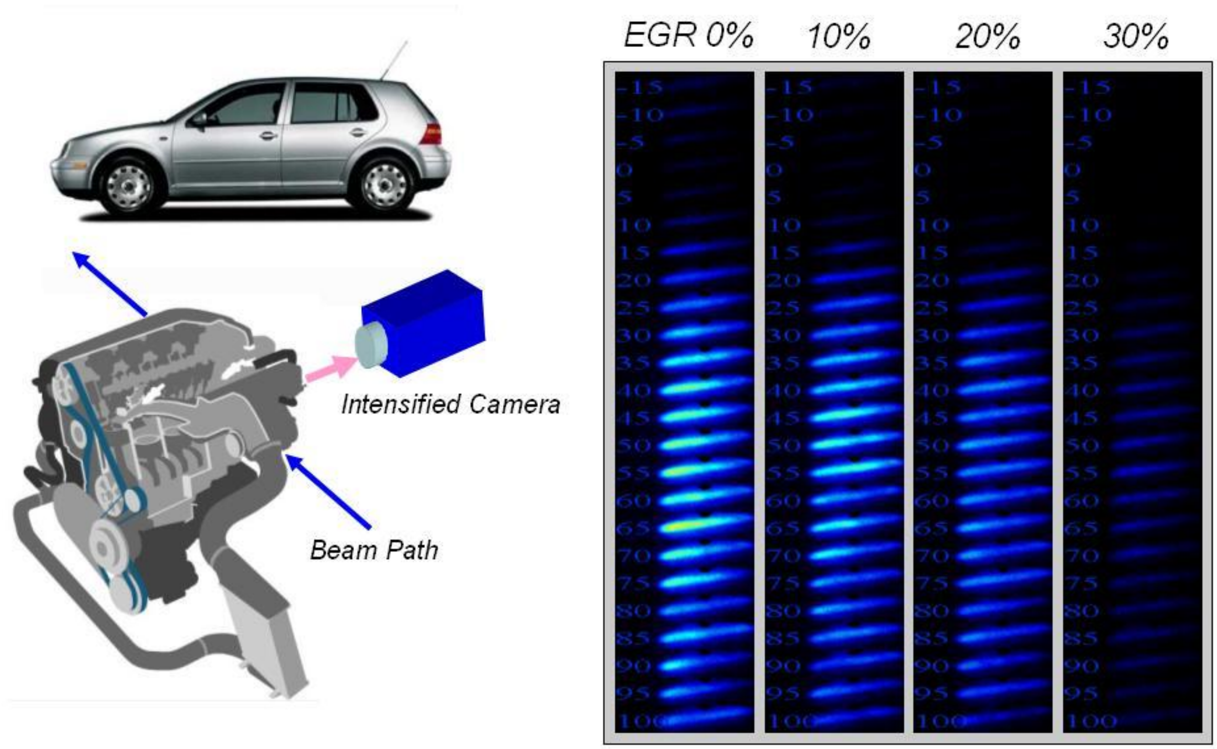

Figure 6: Quantitative NO-LIF imaging in internal combustion engine

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