流体科学研究所

「エネルギークラスターセミナー」開催のお知らせ

この度，流体科学研究所のエネルギークラスター活動の一環として，オハイオ州立大学の Adamovich 教授をお招きし，下記の通り「エネルギークラスターセミナー」を開催することとなりましたのでご案内申し上げます。
先生のご講演では,「プラズマ燃焼促進のためのナノパルス放電中のプラズマ化学反応およびエネルギー輸送過程」に関する話題をご提供いただきます。
皆様のご参加をお待ち申し上げております。

日時：平成 25 年 6 月 5 日（水）13：30－15：00

場所：GCOE 棟 3 階セミナー室

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題目："Challenges in kinetic modeling of energy transfer process and plasma chemistry in nanosecond pulse discharges in reacting gas mixture"

概要：次ページをご参照ください。

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Challenges in kinetic modeling of energy transfer processes and plasma chemistry in nanosecond pulse discharges in reacting gas mixtures

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The objective of the present work is to provide quantitative insight into plasma chemical reactions in fuel-air mixtures at low temperatures; coupling between excited electronic states and vibrational excitation of molecules in the ground electronic state; and chemical reactions stimulated by vibrationally excited molecules. For this, two experimental cases are analyzed using plasma kinetic modeling.

Laser Induced Fluorescence and psec CARS diagnostics are used for time-resolved temperature and absolute OH number density measurements in lean H_2-air, CH_4-air, C_2H_4-air, and C_3H_8-air mixtures in a nanosecond pulse discharge cell / plasma flow reactor. The premixed fuel-air flow in the reactor, initially at T_0=500 K and P=100 torr, is excited by a repetitive nsec pulse discharge in a plane-to-plane geometry, operated in burst mode. Vibrational nonequilibrium at these conditions is not a significant factor. The experimental results are compared with kinetic modeling calculations using plasma / fuel chemistry model employing several H_2-air and hydrocarbon-air chemistry mechanisms. Kinetic mechanisms for H_2-air, CH_4-air, and C_2H_4-air developed by A. Konnov provide the best overall agreement with OH measurements. In C_3H_8-air, none of the hydrocarbon chemistry mechanisms agrees well with the data. The results show the need for development of an accurate, predictive low-temperature plasma chemistry / fuel chemistry kinetic model applicable to fuels C_3 and higher.

Nsec pulse discharge in point-to-point geometry is used to study energy transfer processes in nitrogen and air plasmas. The discharge is sustained between two spherical electrodes P=100 torr, generating stable and diffuse plasma channel 2-3 mm in diameter. This approach makes possible achieving high specific energy loading per pulse, up to ~0.5 eV/molecule, with significant fraction of energy stored in the internal molecular energy modes, as well as in N_2 and O_2 dissociation products. Laser diagnostics is used to characterize the plasma with high spatial and time resolution, including psec CARS and spontaneous Raman spectroscopy for rotational temperature and N_2 vibrational level populations measurements; and calibrated Two-Photon Absorption Laser Induced Fluorescence for absolute N, O, and NO number density measurements. The results are compared with kinetic modeling calculations, using a state-to-state master equation model. The results demonstrate that post-discharge, the total quanta in N_2 vibrational levels (up to v=12) increases, by up to ~60% in air and by up to a factor of ~2 in nitrogen, in contrast to modeling results which predict the number of quanta to be constant until decaying by vibration-translation (V-T) relaxation and diffusion. Detailed comparison shows that 1-10 μsec after the discharge pulse, the experimental populations of vibrational levels $v \geq 2$ greatly exceed modeling calculations, which predict their decay due to net downward vibration-vibration (V-V) transfer. This is at variance with the experiment, which shows an increase in the populations of levels v=2-9, reaching a maximum 10-100 μsec after the pulse. These results suggest that a collisional process is feeding N_2 vibrational levels at a rate comparable to the rate of net downward V-V energy transfer. A likely candidate for the source of additional vibrational quanta is quenching of metastable electronic states of nitrogen. The coupling between electronic and vibrational energy modes in nitrogen may also strongly affect rates of plasma chemical reactions and energy thermalization in nsec pulse discharges.