Spectroscopic Examination Of Vibrational And Rotational Properties of NO($A^2\Sigma$) Metastable State From NO γ–Band Spectra By Using Microwave Discharge N_2-O_2 Mixture Plasma

Hao Tan, Atsushi Nezu, Haruaki Matsuura and Hiroshi Akatsuka
Tokyo Institute of Technology, 2-12-1-N1-10, O-Okayama, Meguro-ku,Tokyo 152-8550, Japan

The γ-band radiation is originated from the electronic transition from NO $A^2\Sigma$ metastable state to $X^2\Pi$ ground state. We carried out a theoretical calculation of the γ-band radiation. By using the optical emission spectroscopic measurement method, we experimentally examined the the γ-band spectrum emitted from microwave discharge N_2-O_2 mixture plasma. Then, we fit the observed spectrum with our calculation, so that the vibrational and rotational temperatures of NO $A^2\Sigma$ state were obtained.

The N_2-O_2 plasma is generated by a microwave discharge with its frequency 2.45 GHz, and the output power is set at 400 W. The total pressure of the plasma ranges from 0.5 to 2 Torr. A CCD spectrometer (200 to 850 nm) is applied as a polychromator for the measurement of the emission spectra.

From the experimental results, it is found that both NO and N_2 molecules in the mixture plasma experience cooling down processes as the flowing distance increases both on vibrational and rotational temperatures.

On the other hand, NO molecules have always the higher rotational temperature than N_2, and the rotational damping process is slower than that of the vibration. It implies that the rotational excitation kinetics of NO molecule is different from N_2. As we know, NO molecules in N_2-O_2 mixture plasma come from collisions among a variety of molecules and atoms. All the collisions can lead to a faster rotation than N_2, whose rotation motion mostly is generated from collisions with electrons mostly.

When O_2 molar ratio of the mixture increases, the NO experiences an increasing vibrational temperature. This is because that the NO $A^2\Sigma$ metastable state is excited from two main paths: one is the collision between NO $X^2\Pi$ with free electrons and the other is the collision between NO $X^2\Pi$ and N_2 $A^3\Sigma$. These two ways have different vibrational exciation processes, and the collision between NO $X^2\Pi$ and N_2 $A^3\Sigma$ appears a vibrational energy exchange [1]. Hence, when the participator density changes, the NO $A^2\Sigma$ vibration property should depend on a molar ratio of O_2.

[1] B.F. Gordiets, C.M. Ferreira, V.L. Guerra, J.M.A.H. Loureiro, J. Nahorny, D. Pagnon, M. Touzeau, M. Vialle, *IEEE Trans. Plasma Sci.,* **23**, no.4, pp. 750-768 (1995)