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SPATIAL DISTRIBUTION OF VIBRATIONAL TEMPERATURE IN THE GRIMM-TYPE GLOW DISCHARGE

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1. INTRODUCTION

Optical emission spectroscopy (OES) was used for determination of the vibrational temperature from the spectra of nitrogen molecule. Relative intensities of vibrational emission sequences are used to determine vibrational temperatures for the Second Positive System of molecular N_2 $C^3\Pi_u$-$B^3\Pi_g$ transition (Δv=-2 sequences).
The method that will be applied here is based on the assumption that the populations of moleculs at the different energy levels follow a Boltzmann distribution. We followed clasical papers (Herzberg G. ,1950) for determination.
We meassured relative band intensities of the Second Positive System in the Grimm type glow discharge. The spatial distribution of intensity of whole band and vibrational temperature of N_2 where determined. The results are presented at different pressures and currents.

2. EXPERIMENT

The experimental setup is presented schematically in Fig. 1. Our discharge source, a modified Grimm GD is laboratory made and described in detail elsewhere (M. Kuraica et al, 1992). Here, for completeness, minimum details will be given.

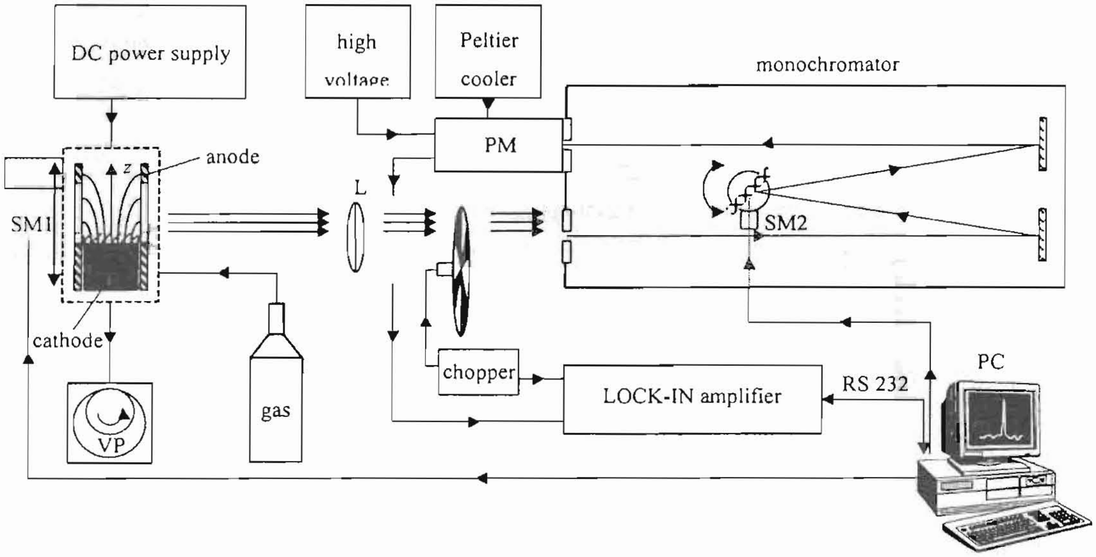

Fig. 1. Schematic diagram of the central part of Grimm GDS and experimental setup for side-on observations. Symbols: VP - vacuum pump, SM 1 and SM 2 - stepping motors L – lens, PM - photomultiplier.

The hollow anode 30 mm long with inner and outer diameters 8.00 mm and 13 mm, has a longitudinal slot (15 mm long and 1 mm wide) for side-on observations along the discharge axis. The water-cooled cathode holder has an exchangeable iron electrode, 18 mm long and 7.60 mm in diameter, which screws tightly into its holder to ensure good cooling. A gas flow of about 300 cm^3/min of nitrogen (99.995%) is sustained at variabile pressure means of needle valve and a two-stage mechanical vacuum pump. To run the discharge a 0-2 kV, 0-100 mA current stabilized power supply is used. A ballast resistor of 10 kΩ is placed in series with the discharge and the power supply.

The radiation from the discharge source is focused with unity magnification (8 cm focal length achromat lens) onto the entrance slit of the scanning monochromator-photomuliplier system, see Fig. 1. For spectral line intensity axial distribution measurements, the discharge tube is translated in ≈0.1 mm steps by a stepping motor, so that the discharge image obtained through the observation slot is translated in the plane of the entrance slit (30 μm) of the monochromator. For the spectral recordings, 4 m Hilger and Watts Ebert type spectrometer with inverse dispersion of 0.242 nm/mm is used. All spectra are recorded with 30 μm entrance and exit slits, giving a Gaussian instrumental profile with 0.020 nm half-width. The monochromator is equipped with a stepping motor, which enables minimum wavelength change in steps of 0.0028 nm. For radiation detection, a photomultiplier with Peltier cooling is used. A lock-in signal amplification technique is employed. the entire experiment is controled by a PC. The same computer is used for data acquisition.

3. RESULTS

In this paper are presented results of spatial distribution of whole band intensity and vibrational temperature determination (as example Fig. 3) in the Grimm discharge with an iron cathode. The observation were performed side-on.

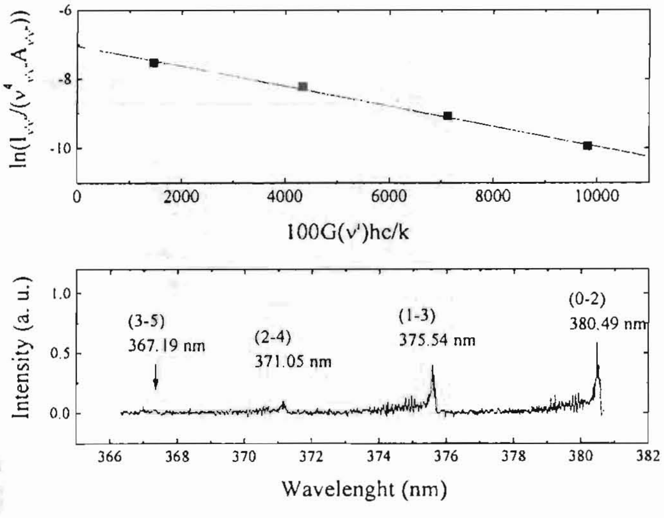

Fig. 2. Emission spectra of the Second Positive System of N_2, sequences (Δv=-2) and a Boltzmann plot with corresponding vibrational temperature T_{vib}=3400 K.

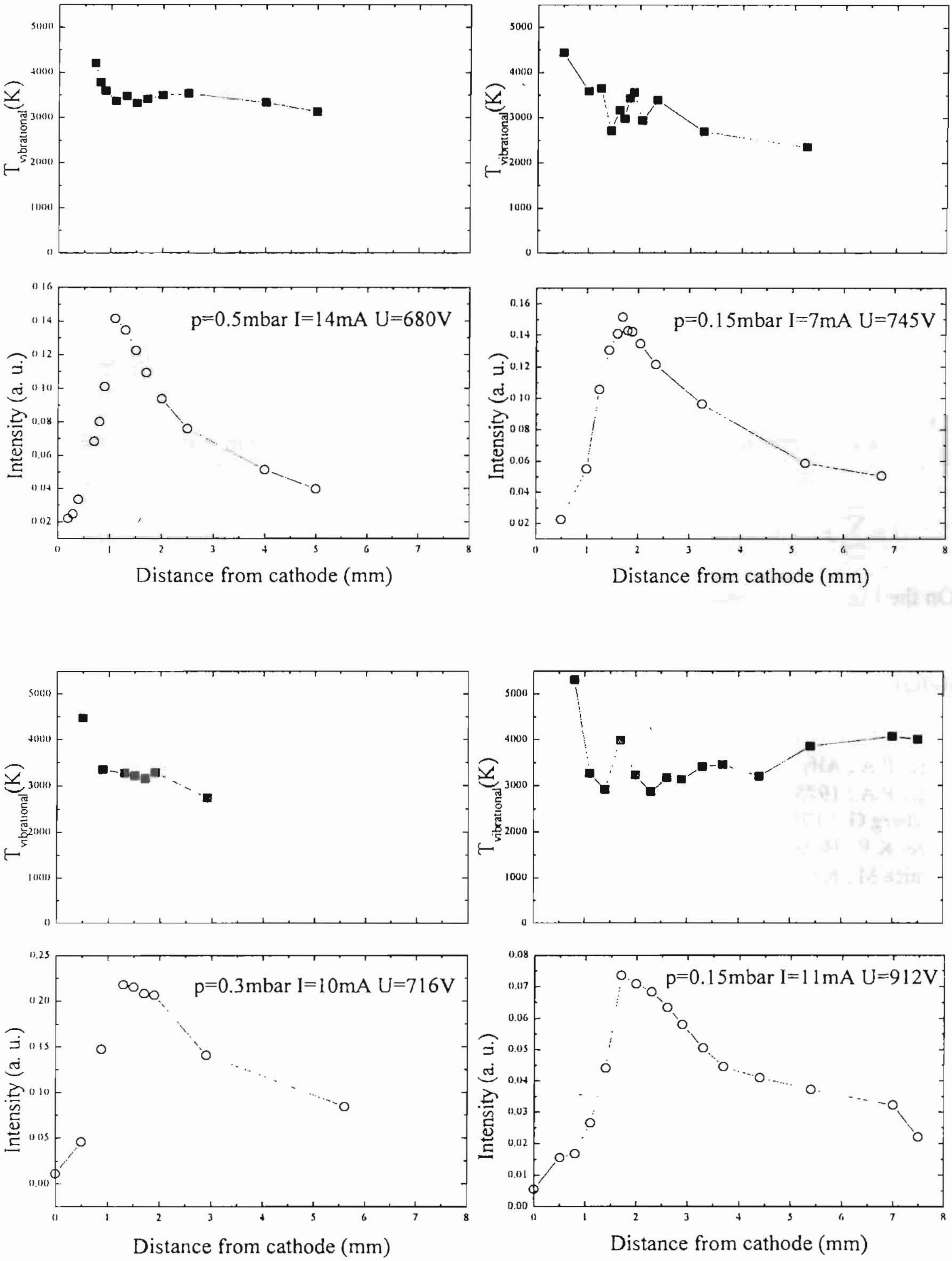

Fig. 3. Spatial distribution of T_{vib} and whole band intensity of the Second Positive System of N_2 sequences (Δv=-2), 380.49nm.

The method of determining a "vibrational" temperatures has been applied for the Second Positive Sistem of the N_2 molecule which is $C^3\Pi_u$-$B^3\Pi_g$ transition, for vibrational sequences (Δv=-2) : (0-2), (1-3), (2-4), (3-5) (Fig .2).

Relatively intensities of rotational-vibrational band is given (Herzberg G. ,1950 , Büger P.A., Alfy S. El., 1975, Büger P.A., 1975) as

$$I_{v'v''} = D \cdot \frac{N}{Q_v} \cdot e^{-\frac{G(v')\cdot hc}{kT}} \cdot \nu^4{}_{v'v''} \cdot A_{v'v''}$$

By plotting $\ln \frac{I_{v'v''}}{\nu^4{}_{v'v''} \cdot A_{v'v''}}$ against $100 \cdot G(v')\frac{h \cdot c}{k}$ a straight line is obtained whose slope is $\frac{1}{T_{vib}}$. G(v') is term velues for upper vibrational level (v') given with Dunham coefficients:

$G(v') = \sum_{i=1}^{n} y_{i0}(v + \frac{1}{2})^i$ in cm^{-1} as in (Laux C. O. and Kruger C. H. , 1992).

On the Fig.3 are presented results taken on three pressures and one of them is on two currents.

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