Gas temperature distribution in cathode fall region of hydrogen Grimm glow discharge

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Optical emission spectroscopy technique is used to measure gas temperature distrubition in cathode fall (CF) region of an abnormal type glow discharge operating in hydrogen at low pressure. For the gas temperature estimation, the Q branch of electronic transition $d^3\Pi_u^-, v'=0 \rightarrow a^3\Sigma_g^+, v''=0$ (Fulcher-α diagonal band) is recorded and analyzed in the cathode fall region of the Grimm type glow discharge. The rotational temperature of ground vibrational state $T_0(n', v')$ determined from the rotational population density distribution in an excited (n', v') vibrational state can be considered as a valid estimation of the ground state rovibrational temperatutre i.e. H_2 translational temperature T_{tr}.

1. Introduction

Within the growing number of applications original Grimm design glow discharge source (GDS) is successfully used as an excitation source for analytical spectroscopy of metal and alloy samples.

The knowledge of discharge parameters in CF region (the electric field distribution, excitation temperature, translational gas temperature T_{tr} of molecules etc.) is of particular importance for characterization of Grimm GDS.

Here, Fulcher-α diagonal band is recorded and analyzed in the cathode fall region of glow discharge in hydrogen for the gas temperature mapping.

2. Experimental

A detailed description of a modified Grimm GDS source and experimental setup is given in [1]. The experiment has been realized in hydrogen (purity 99.999%). The axial intensity distribution of radiation is observed side-on through the anode slot. The discharge tube was translated in steps d=0.125 mm. All measurements of molecular spectra are performed with an instrumental profile very close to Gaussian with full width-at-half-maximum (FWHM) of 0.014 nm in the second diffraction order. Signals from thermoelectrically cooled CCD detector (2048 × 506 pixels, pixel size 12 × 12 μm, -10 ºC) are collected and processed by PC.

3. Results and discusion

The temperature obtained from Q branch of Fulcher-α band may be considered as the most reliable for the temperature estimation, see details in Ref. 2. The Q branch lines of the electronic transition $d^3\Pi_u^-, v' \rightarrow a^3\Sigma_g^+, v''$ $(v' = v'' = 0)$ are well resolved and have high enough intensities in the 595-645 nm wavelength region. So, Boltzmann plot technique is used for evaluation of rotational temperature T_{rot} (n', v') of the excited state. Within the framework of model discussed in [3], the temperature recalculated for the ground vibrational state $X^1\Sigma^+_g, v = 0$ is two times larger than the rotational temperature of excited states since the rotational constants for the upper and ground states are (30.364 cm^{-1}) and (60.853 cm^{-1}), respectively. The results obtained for gas temperature T_{tr} distribution along the CF region are presented in Figure 1.

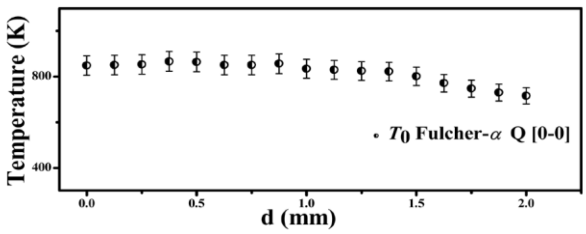

Figure 1. The axial distribution of gas temperature of the H_2 ground state $X^1\Sigma^+_g$. Experimental conditions: p = 4.5mbar; I = 13.4 mA; U= 775 V.

4. References

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