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ROTATIONAL TEMPERATURES AT ATMOSPHERIC PRESSURE OF MICROWAVE INDUCED PLASMA

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1. INTRODUCTION

In this paper we report the results of radial distribution of rotational temperature (T_{rot}) measurement in an atmospheric MIP with tangential flow stabilization. The rotational temperatures are determined from the relative intensities of OH (R_2 and Q_1 branch) electronic band $A^2\Sigma - X^2\Pi$ (0,0). The measurements of rotational temperatures from an to N_2^+ first negative system $B^2\Sigma_u^+ - X^2\Sigma_g^+$ (P and R branch) are in progress.

2. EXPERIMENTAL

In the present paper we report measurements performed in the tangential flow stabilized MIP. The instrumental components are summarized in Table 1.

Table 1. Instrumental apparatus and components

Component	Specification
Microwave generator	2.45 GHz model: GMW 24 - 302 DR
Microwave cavity	TEM_{010} Beenakker type - Van Dalan modification : HMW 25-471
Discharge tube	Mini-MIP-Torch tangential flow Al oxide (6 / 4 mm) (model M52-203)
Nebulizer	right-angle pneumatic nebulizer Meinhard TR30-C3, (SPETEC,Germany)
Monochromator	0.5 m Ebert type (Jarrell Ash 82-025)
Photomultiplier	EMI 9659QB
Picoammeter	Keithley 414 S
Boxcar averager	Stanford Research Systems SR 250
Mirrors M_1 and M_3	Plain with aluminized surface
Mirror M_2	Focal length 50 cm with aluminized surface
Lens	Quartz lens, 8 cm focal length, diameter 2.5cm
X-Y Table	ISEL-automation, Germany

In order to obtain discharge which is temporally and spatially stable we exchange single capillary discharge tube with so called "tangential flow torch" reported by A.Bollo-Kamara [1]. Instead of quartz concentric tubes and thread insert which are fused all together, we used alumna tubes separated by cooper wire. Windings of the wire are the same as a coils of theirs threaded insert. Analyte sample gas goes through the inner tube, while the plasma support gas is introduced through the outer sleeve and exit from the cooper wire windings with a spatial trajectory. In such a manner, temporally and spatially discharge which is separated from the walls was obtained. Also a discharge wall etching and consequence memory effect are decreased and tube lifetime was prolonged.

For all experiments, argon with continuous flow of $200scm^3/min$ is used as a support gas. The forward microwave power of 100 W is also used throughout, while the reflected power never exceeded 3 W. The argon nebulizer gas flow of $20\ scm^3/min$ is always sustained, but under different conditions, see Table2.

The laterally measured intensities are converted into radial intensities by performing the Abel inversion [2].

Table 2. Experimental conditions

	Nebulizer gas	Support gas	Gas condition
1	Ar+H_2O	Ar	Wet
2	Ar+H_2O	Ar+2.7%H_2	Wet
3	Ar+(KCl+H_2O)*	Ar	Wet

* water solution of KCl – 1, 2 and 4 mg/ml

3. RESULTS

The rotational temperatures were determined from relative radiance's of $A^2\Sigma$ - $X^2\Pi$ (0,0) electronic band of OH (R_2 and Q_1 branch) see Fig 1. In order to draw the Boltzmann plots transition probabilities data for OH , are taken from Ref. [3], see Table 3.

Table 3. Wavelengths, excitation energies and rotational transition probabilities of the R_2 and Q_1 branches of OH (0-0) rotational band $A_2\Sigma^+ \rightarrow X_2\Pi_i$

Lines	λ [nm]	A_k [10^8s^{-1}]	E_k [cm^{-1}]	Lines	λ [nm]	A_k [10^8s^{-1}]	E_k [cm^{-1}]
R_21	308.4	2.7	32542	R_216	307.5	61.3	37440
R_22	308.02	5.7	32643	R_217	307.81	65.3	38004
R_23	307.70	8.9	32778.49	R_218	308.13	69.3	38594
R_27	307.43	12.8	32947.05	R_219	308.49	73.4	39209
R_28	306.91	24.8	33650.38	R_220	308.9	77.4	39847
R_28	306.82	28.8	33949.67	Q_11	307.84	0	32475
R_213	306.96	49.1	35911.58	Q_12	307.95	17	32543
R_214	307.11	53.2	36393.24	Q_14	308.33	33.7	32779
R_215	307.3	57.2	36902.9	Q_15	308.52	42.2	33150

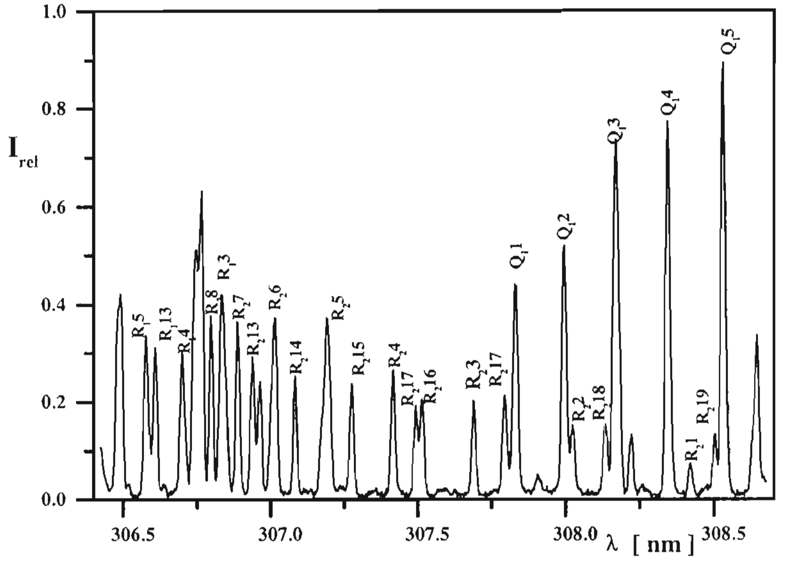

Figure 1. Spectrum of the OH (0,0) band emitted by the wet Ar nebulizer gas and Ar support gas at H=2000μm and from the central portion of MIP.

The typical example of the Boltzmann plot is in Fig.2, while the radial distribution of rotation temperature is given in Figure 3.

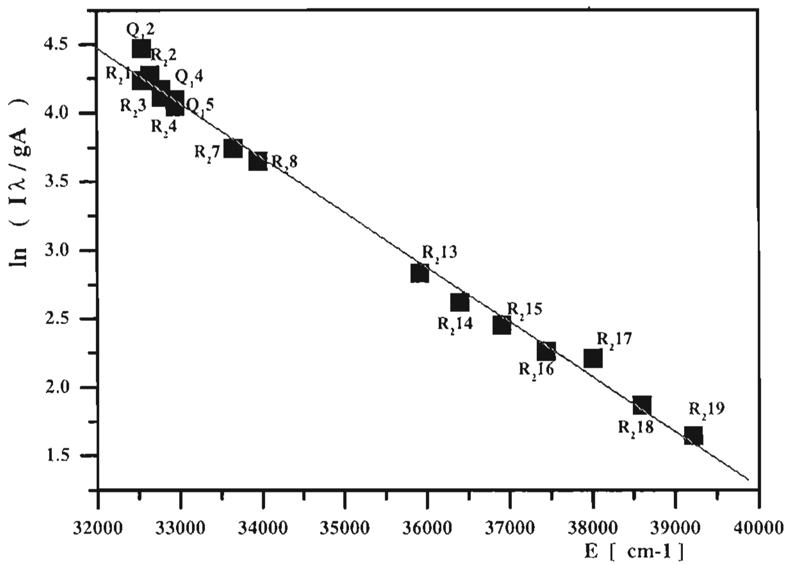

Figure2. Boltzmann plot of R_2 and Q_1 branches of OH (0-0) rotational band emitted by the wet Ar nebulizer gas and Ar support gas at H=2000μm and from the central portion of MIP.

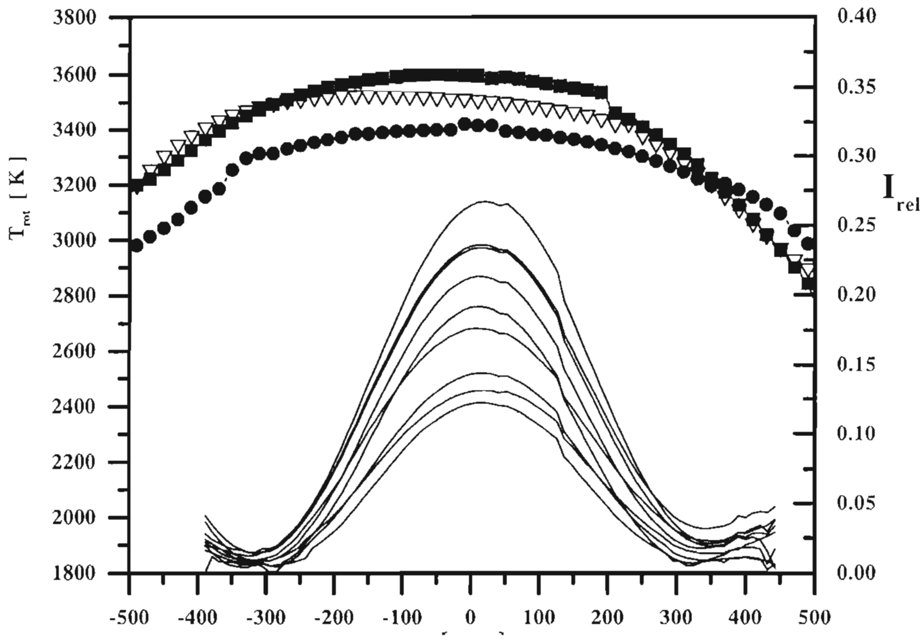

Figure 3. Radial distribution of rotational temperature and integral intensity of some OH band lines with nebulizer gas: (•)wet argon with argon as a support gas; (•) wet argon with argon – hydrogen mixture as a support gas; (∇)wet argon with 2mg/ml KCl and argon as a support gas.

The comparison of results in Fig.3 show that with the studied changes of nebulizer and support gas the radial distribution of rotational temperature remains constant, while the maximum temperature of 3 500 K do not change more than 200 K, what is within the limits of the estimated error of temperature determination.

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