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ELECTRON DENSITY DIAGNOSTICS IN AN ATMOSPHERIC PRESSURE HELIUM MICROWAVE-INDUCED PLASMA

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Abstract. In this paper we present the results of the electron density measurements in an atmospheric pressure microwave-induced discharge. For this diagnostics we use two independent spectroscopic methods for plasma electron diagnostics : H_β line profile and from the He I 447 nm line and its forbidden component. Good agreement between these two methods is obtained. The electron concentration in the vicinity of the plasma axis between 1.9 and $3.6 * 10^{20} m^{-3}$ with microwave power input of 80W was determined.

1. INTRODUCTION

The low-power microwave-induced plasmas (MIP) were found to be very advantageous sources for atomic emission spectrometry (AES). The attractiveness of these plasmas lies in their high electronic temperatures, especially when He is used as plasma gas, allowing efficient population of high-lying excited levels of non-metals to be. In addition, the low cost of instrumentation and operation for conventional atmospheric pressure MIP makes these sources particularly attractive for element analysis. Although MIP was used in AES for almost 20 years, there is only a few papers reporting the results of plasma parameters studies (see e.g. Goode et al. 1994, Tanabe 1983 and reference therein). All reported electron density (Ne) determinations are based on the measurements of the H_β line profiles. Here, we presents the results of the HeI 447.1 nm and its forbidden component line profile measurements, as a new candidate for plasma diagnostics in this type of plasmas.

2. EXPERIMENT

Schematic diagram of the experimental setup is presented in Fig.1 As a power supply commercial 2450 MHz generator connected by the coaxial cable to the TEM_{010} type microwave cavity described by Beenakker (1977) is used. Helium flow through the 3 cm long quartz discharge tube (I.D.1.5mm, O.D. 3mm) and right-angle pneumatic nebulazer is adjusted by the mass flowmeter and regulator. A 1 : 1 image of the plasma source is projected on the (20 μm wide and $1mm$ high) entrance slit of 0.5 m Ebert type spectrometer (Jarrell Ash 82-025) with inverse dispersion 1.6 nm/mm. Spectra recordings were performed by the use of photomultiplier EMI 9659QB mounted on the exit slit of the spectrometer. The wavelength scanning was performed by the step motor and step motor drive (Isert ID 3304) controlled with PC AT computer. The spectral line shapes are recorded by the help of boxcar averager (Stanford Research Systems SR 250) and the same computer. For enhancement of the signal to noise ratio, averaging of 10 signals at each step of the motor was also performed.

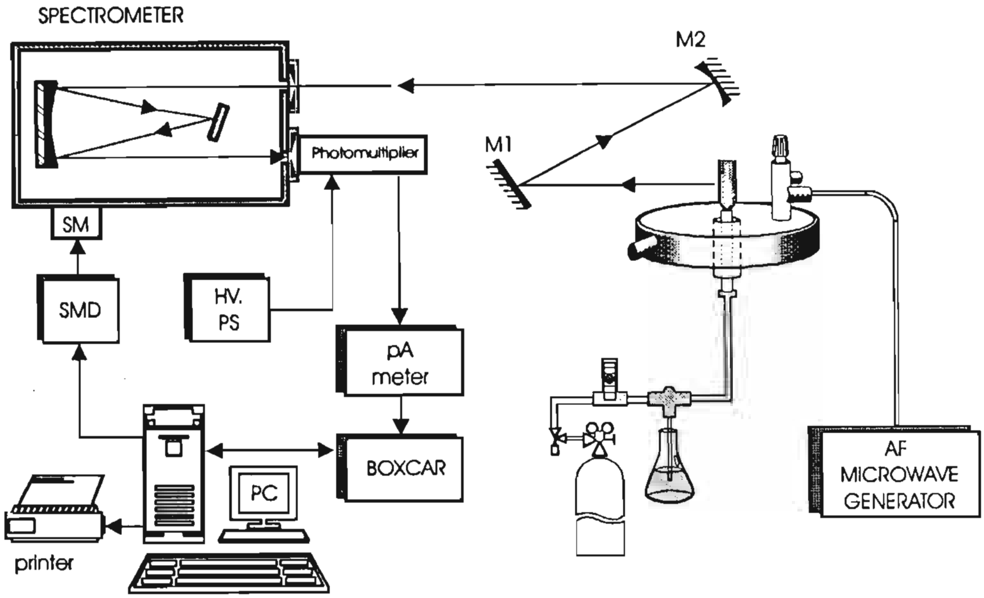

Fig. 1. Schematic diagram of the experimental setup.

3. RESULTS AND DISCUSSION

Side-on measurements of line shapes of H_β spectral line and HeI 447.1 nm and its forbidden component 5mm above the top of the quartz discharge tube was performed. The radial distribution of studied line profiles from the layers 0.05 mm apart are shown in Figures 2 and 3. In all cases helium flow was 0.75 l/min and forward microwave power 80W. For separation of the contributions from different plasma layers and to obtain the true radial plasma intensity distribution we used Abel inversion procedure as developed by Djurović et al., (1996). Electron density is determined from the fitted H_β spectral line profiles in conjunction with the theoretical calculations by Vidal et al (1973). From the recordings of 447.1 nm line shape electron density Ne is determined by using empirical formula (Czernichowski and J. Chapelle ,1985)

$$\log Ne = 23.056 + 1.586 \log(S - 0.156) + [\log(S - 0.156)]^2$$

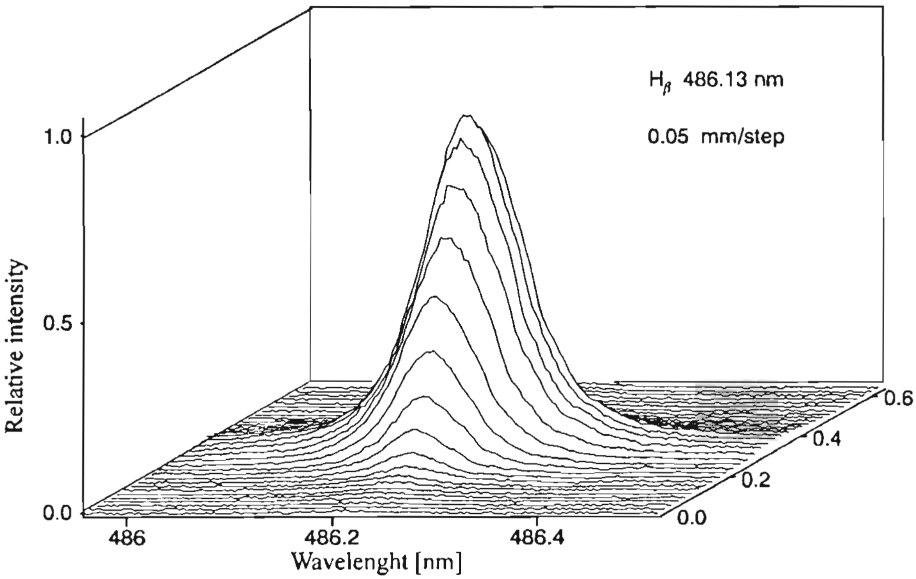

Fig. 2. Radial distribution of the H_β line profiles from layers 0.05 mm apart.

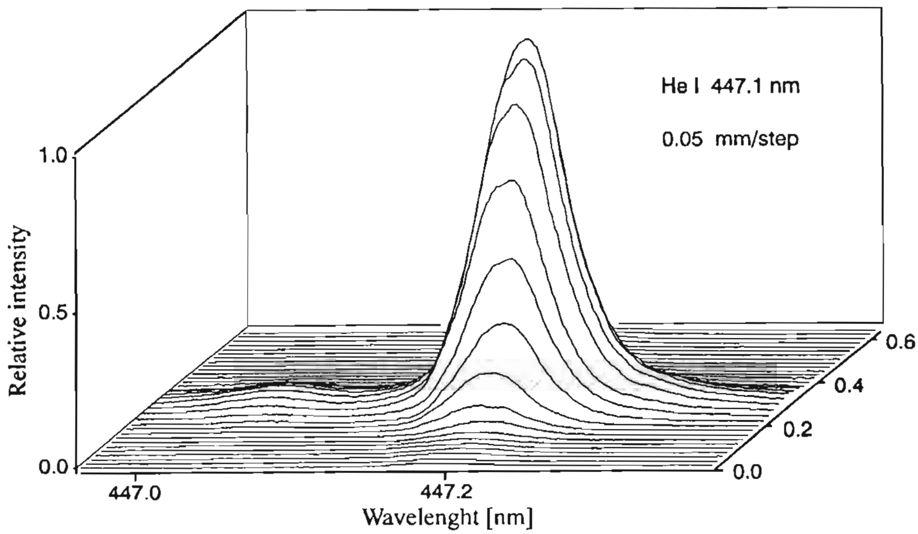

Fig. 3. Radial distribution of the He I 447.1 nm line profiles from layers 0.05 mm apart

The obtained results of the radial dependence of electron density concentrations are presented in Figure 4. Densities between 1.9 and 3.6 $* 10^{20}m^{-3}$ are determined. Also a good agreement between this two methods is found.

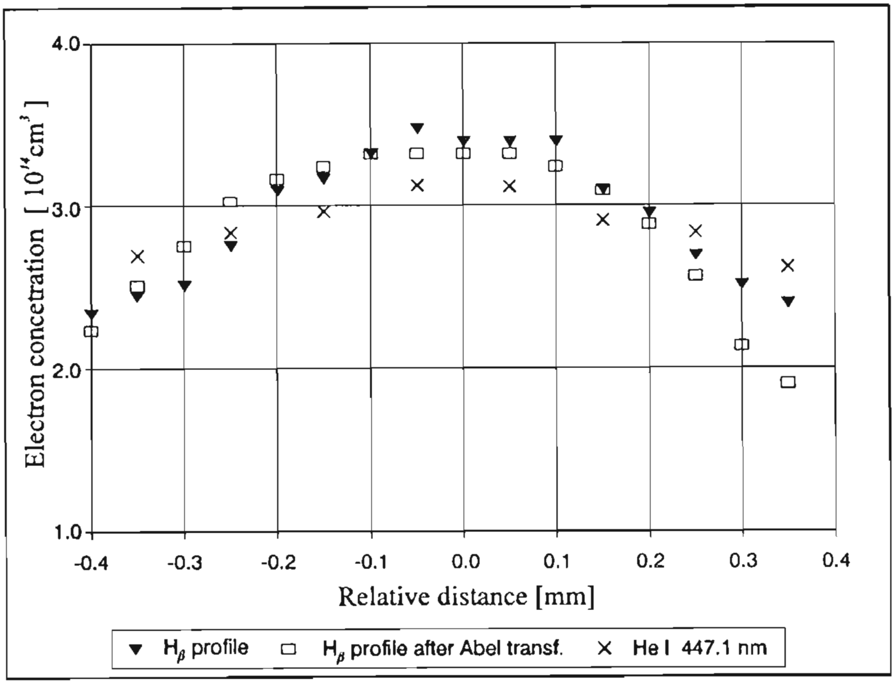

Fig. 4. Radial dependence of the Ne obtained from the different line profiles

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