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TANGENTIAL FLOW MIP SOURCE WITH DESOLVATION SYSTEM

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Abstract. In this paper we present the description of a tangential flow microwave induced plasma source witch enables generation a temporally and spatially stable discharge, located in the center of the discharge tube. In such a configuration etching of the tube walls and thermal losses are greatly reduced. The desolvation systems which is also described enables enhancement of the detection limits of analytical species, whose spectral lines are overlapped by OH bands.

1. INTRODUCTION

After the introduction of the Beenakker (1976) cylindrical resonant cavity microwave-induced plasmas (MIP) has received considerable attention as an excitation source for atomic emission spectroscopy (see e.g. Q. Jin et al. 1997). This cavity, which operates at 2.45 GHz in the TM_{010} mode, make possible the generation of a plasma at atmospheric pressure in argon or helium. Further modification of this cavity by Van Dalen et all. (1978) enables more efficient excitations of various elements in aqueous solutions.

It was noticed that at input power above 50 W plasma moves to the wall of the tube. Same spatial distortion of the plasma is observed at higher support gas flow rates also. This characteristic of MIP has several detrimental effects. Plasma, which touches the inner wall of the discharge tube will etch the wall, and shortens the tube lifetime. Etching may also lead to analyte memory effects due to occlusion of salt particles at the etched surface. The plasma also has a tendency to wander about the inner wall of the discharge tube making difficulties to couple the plasma image to a monohromator. Therefore, it would be desirable to obtain a plasma discharge which is temporally and spatially steady and which do not lie along the discharge tube wall to reduce etching and thermal losses.

The introduction of aqueous solution of investigated samples results in a existence of very intense OH bands. Such a bands overlap low intensity spectral lines of analytical samples, and in this way reduce detection limits. For some elements this problem is so pronounced that analytical line detection is practically impossible. In such case it is desirable to remove water from sample gas before entering discharge vessel. The method for obtaining dry and spatially and temporally stable plasma is presented in this paper.

2. EXPERIMENT

We used commercially avaiable Van Dalen et all. (1978) modification of the Benakeers (1976) cylindrical resonant cavity (model HMW 25-471) supplied via coaxial cable by the 300 W, 2.45 GHz microwave generator GMW 24-302DR (both

produced by AHF analysentechnik, Tübingen,Germany). The resonant cavity with inner diameter 88 mm and depth 7.65 mm is made from silver electroplated brass. The microwave power is coupled into the cavity by the inner conductor of the coaxial cable, which ends like an antenna inside the cavity. Variable capacitive coupling is obtained by variation of distance between end of the antenna and opposite wall of the inner part of the cavity. This allows transformations of the plasma impedance to the impedance of the coaxial cable and getting an optimal matching of the load to the generator. Tuning of the cavity resonance frequency, is acheived by adjusting the radially mounted ceramic stub, in order to compensate dielectric effects induced by different plasma conditions.

Tangential flow torch In applied configuration spatial distortion is eliminated by using discharge tube similar to the tangential flow MIP torch reported by A. Bollo-Kamara (1985). This torch, constructed entirely from quartz, utilizes a concentric tube arrangement, with a thread insert to generate a tangential flow. The thread is fused to the inner and then sealed to the outer tube. We also use two concentric tubes, made from Al oxide, separated by the cooper wire (see Fig 1). These tubes (outer diameters 4 and 2mm) are fixed by stainless steel body and holding nut via graphite gasket. Windings of the cooper wire are the same as coils of a A.Bollo-Kamara (1981) threaded insert.

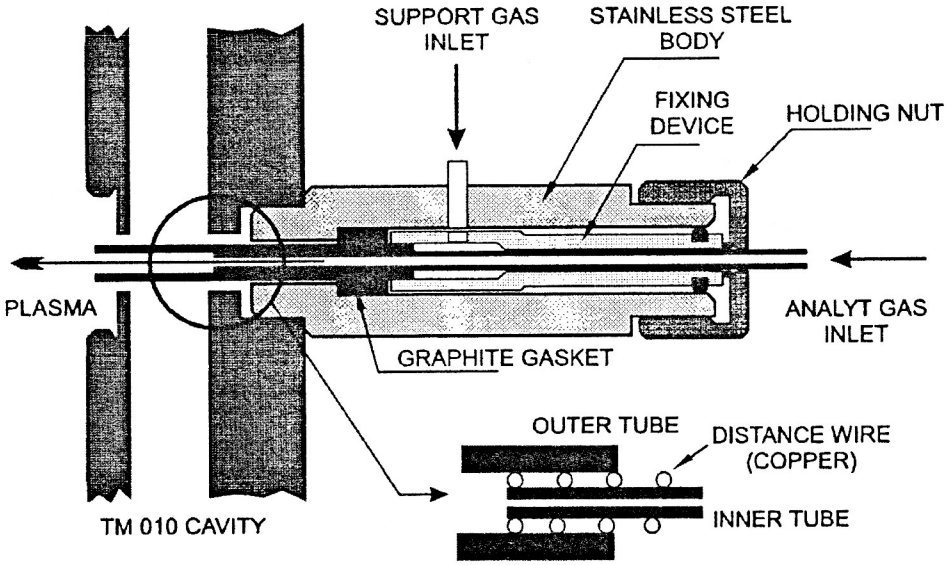

Figure 1. Cross section of tangential flow MIP torch

The optimal positioning of the Al oxide tubes are shown in Figure 1. 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 spiral trajectory. In such a manner, by increasing the flow rate of support gas, discharge behaves as a rod like filament, suspended in the center of the discharge tube, extending the length of the cavity. Once this so called "suspended plasma" is formed the gas flow

rate can be decreased to the lower values. The obtained discharge is spatially and temporally stable and separated from tube walls.

Desolvation system This used desolvation system is similar to the one described by Veillon et all. (1968) see Figure 2. It consists of right angle pneumatic ICP nebulizer, spray chamber, evaporating chamber and modified Liebig-Graham condenser.

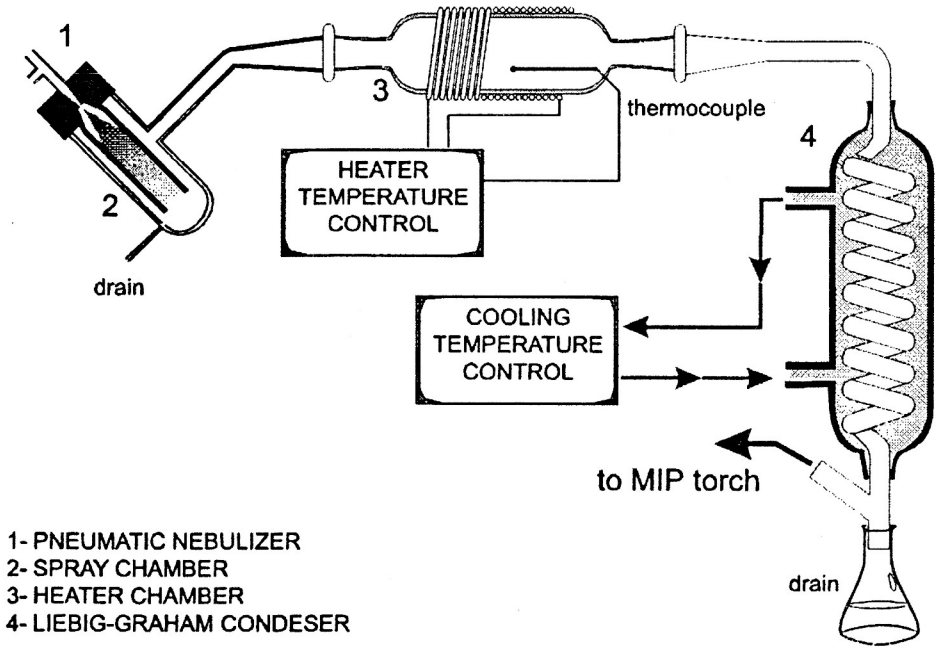

Figure 2. The desolvation system

For generation of aerosols from aqueous solution of analyzed samples we used Meinhard right angle pneumatic ICP nebulizer. Aerosols produced from this nebulizer have both extremely wide drop size ranges and very turbulent gas flow patterns [Browner et all,1984]. In order to reduce in this way generated random fluctuations of spectral line intensities dual tube Scott-type (1974) spray chamber was used [see Fig.2]. The purpose of the central tube is to separate the forward and reverse aerosol flows, the latter produced as a result of the low pressure in the region of high aerosol velocity. Evaporation of water was realized by the use of glass chamber heated to the temperature of 300 C and controlled by thermocouple and corresponding electronics. The water vapor is then condensed by Liebich Graham condenser cooled by water, which temperature is sustained at 3 C. Water droplets are accumulated in the drain and dry gas with analytic sample is lead to the discharge tube. This desolvation system removes water vapor from discharge, what is verified by lowering of the OH band spectra by two orders of magnitude (see Figure 3).

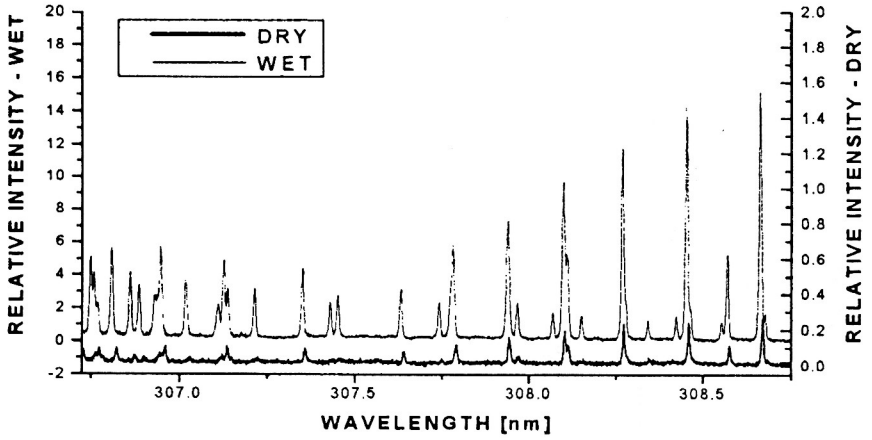

Figure 3. OH band spectra in wet and dry nebulizer gas

Surprisingly a little effects to the intensity of the analytical sample spectral linesis noticed. The drying of the nebulizer gas makes MIP discharge more stable and detection limits enhanced.

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