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LONGITUDINAL EMISSION DIAGNOSTICS OF PLASMA CHANNEL IN RF BARRIER TORCH DISCHARGE

P. Slavíček[1], A. Brablec, V. Kapička, M. Klíma, M. Šíra
Department of Physical Electronics, Faculty of Science, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic

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We present longitudinal emission diagnostics of the plasma channel in the special design of the plasma pencil – rf barrier torch discharge. This configuration has been developed for deposition of thin films on various surfaces. Using optical emission spectroscopy the spectroscopic quantities were determined as well as the longitudinal distribution of rotational temperature in the plasma channel is presented.

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1 Introduction

Different plasma discharge systems with nozzle and powered by rf generator have been investigated during several last years [1]. The advantage of the rf plasma discharges consists in the fact that the torch discharge remains stable up to the atmospheric pressure which is very useful for surface coating and cleaning, spectral analysis, treatment of archaeological glass artifacts, plasma polymerisation in liquids, etc. There are exist many modifications and several nomenclatures; the device for hand employ has been also called plasma pencil.

The plasma pencil is a new plasma-generating device usually driven at rf that was developed when the non-standard problem of archaeological artefact treatment was solved. Special properties of this discharge offer many hopeful technological applications like deposition of thin solid films, cleaning and treatment of surfaces, restoration of archaeological artefacts, etc. It was also demonstrated that the discharges could burn under the liquid level. They can interact with the material and then new chemical compounds can arise. The discharges can be driven in argon or in other gases [2–4]. In fact, there are existing two basic types of arrangements - torch discharge (TD) and barrier torch discharge (BTD). While in case of the TD the powered electrode is the nozzle, in case of the BTD the dielectrics separates the powered electrode and the initial nozzle through which flows the working gas again. The advantage of the plasma pencil is a possibility to work in open atmosphere, in liquid, at reduced or increased pressures, etc.

Here, we present longitudinal diagnostics of plasma channel of special design of plasma pencil – barrier torch discharge (BTD) which has been preferable studied for the deposition of thin

[1]E-mail address: ps94@physics.muni.cz

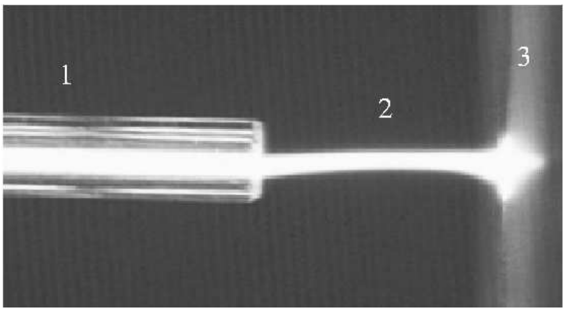

Fig. 1. Photo of the plasma channel: 1- dielectric tube, 2 - plasma channel, 3 - grounded electrode. The channel has been driven usually in vertical orientation but it can burn in any position. The powered electrode is not on the photo.

films and for the treatment of various surfaces. Other versions of dielectric barrier discharges can be found in [5,6] while measurements of various quantities characterised discharges investigated at the Department are presented in [7–9], too.

2 Experimental arrangement

The snapshot of the barrier torch discharge is shown in Fig. 1. The powered electrode is separated by the dielectric tube (in this experimental arrangement the quartz was used) and through this tube flows working gas (argon) - the detail description and discussion were also presented in [1, 10]. The powered electrode was connected through the matching unit to the rf generator (PG - 501, 13.56 MHz). The working gas, argon flowing from the nozzle, stabilised the torch discharge as mentioned in previous papers.

The spectra emitted by the plasma channel were recorded by the Jobin - Yvon, TRIAX550 monochromator, with the CCD Spectrum One detector cooled by liquid nitrogen, for different parameters of the arrangements like rf power, working gas flow, electrode gap, etc. [11, 12].

3 Results and conclusion

Diagnostics of the plasma channel was done by means of emission spectroscopy. The N_2 second positive system $C^3\Pi_u$ - $B^3\Pi_g$, molecular bands of OH (vibrational band 0-0, 306.4 nm system) and atomic lines originating from working gas were found. Typical rotational temperature was about 1000 K while the vibrational temperature was about 3000 K. These values were obtained in the mouth of the nozzle, i.e. for the position zero in Fig. 2.

An interesting behaviour of various components in the discharge was investigated by measuring the selected line intensity. For example, in Fig.3 the intensity of oxygen line (777.543 nm) vs. the distance from end of nozzle is shown. The negative values were taken for the distance in the nozzle. The grounded electrode was placed 8 mm from the end of the nozzle. One can see that even if the working gas was argon, intensive atomic oxygen lines excited by the discharge, were observed far from the end of the nozzle. We also verified that the contamination of the

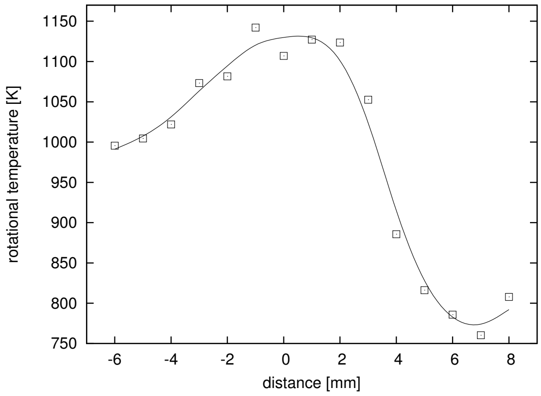

Fig. 2. The rotational temperature estimated from the OH band (0-0 system, Q_1 branch) vs. the distance from the end of the nozzle. Negative distance was in nozzle, positive distance was out of nozzle. The grounded electrode was placed 8 mm from the end of the nozzle, the input power was 100 W. Error of rotational temperature was less than 10%.

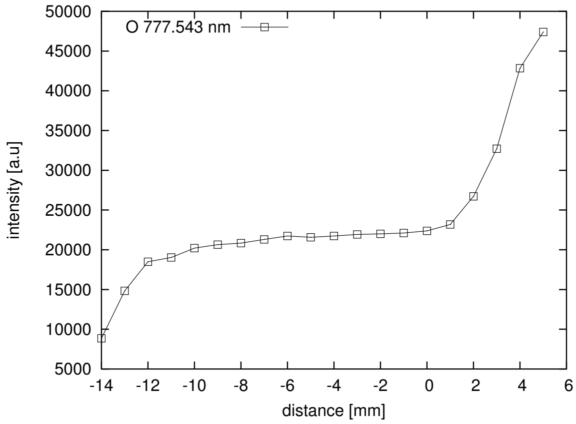

Fig. 3. The relative intensity of oxygen line (777.543 nm) for the input power 100 W vs. the distance from the end of the nozzle. The negative distance was taken in the nozzle while the positive values were taken out of nozzle. The grounded electrode was placed 8 mm from the end of the nozzle. Input power was taken as the output power of rf generator.

discharge by the electrode material does not occur, i.e. the possible sputtering of the nozzle can not influence properties of the plasma channel, which could be a big advantage in comparison with the torch discharge.

The rotational temperature was estimated from the OH band (Q_1 branch) as given above in longitudinal direction, see Fig. 2. The Abel transformation was not taken into account for very small diameter of the plasma channel (smaller than 1 mm).

Measurements of electrical parameters (voltage - current courses) can give additional information. The temporal voltage - current courses will be already presented for the torch discharge for example in [1]. The same measurements have been realized on the BTD in order to estimate phase relations.

In this contribution the single nozzle was used. But, several nozzles can be applied simultaneously in one device [10], which is more convenient for practical application because of larger contact area of the plasma channel with treated surface. The experiments are in progress.

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