Spatially resolved OES study of a microwave plasma in $H_2/CH_4/B_2H_6$

Philippe SUPIOT [(1*)], Joseph PLAVCAN [(1)], Alix GICQUEL [(2)]

[(1)] Laboratoire GePIFReM EA 3571 Univ. LILLE 1 FRANCE

[(2)] Laboratoire LIMHP UPR 1311 Univ. PARIS 13 FRANCE

philippe.supiot@univ-lille1.fr

Introduction

Boron doped diamond films concerns a wide field of applications dealing, for example, with power electronics, sensors, electrochemistry and bio-chips. Among the CVD methods used for film growth, PECVD based on microwave reactors [1] is often used. The subject of the present paper is the study of optical emissions from a plasma sustained in a $H_2/CH_4/B_2H_6$ mixture. In a previous work [2], we mentionned some emitters (H*, H_2*, BH*) which was detected in the plasma ball for commonly used power density conditions for non doped good diamond films (from 9 to 23 $W.cm^{-3}$) [1]. Gas temperature from low resolution BH* emission spectra was studied but no spatial scanning of the species densities was performed in these experiments. In the present work, we seek to fill that void by applying Abel inversion method [3] through spatially resolved emission records. The approach is indeed compatible with the circular-symmetry of the generated plasma.

Experimental section

The experimental set-up is typically similar to the one described in [1,2]. The microwave plasma diamond deposition reactor is made of a fused silica bell jar surmounted by a Faraday cage with a conic antenna. The discharge is sustained with power inputs up to 1500 W by a 2.45 GHz Sairem microwave power supply (3 kW). One pressure–power combination is chosen, 7550 Pa–1500W (23 $W.cm^{-3}$), in order to produce an ball-shaped plasma.

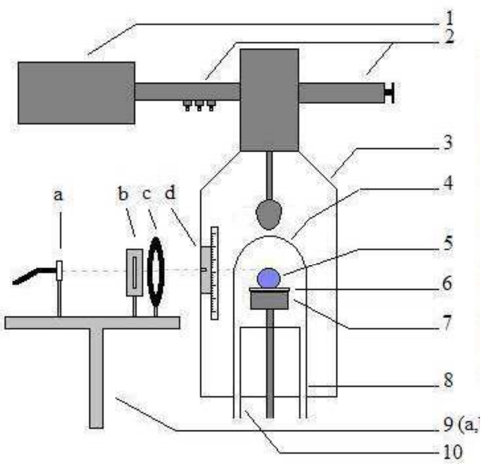

Fig. 1 Experimental set-up: 1- microwave generator (2450 MHz); 2- matching stubs; 3- faraday cage; 4- fused silica bell-jar; 5- plasma ball; 6- substrate; 7- substrate holder; 8- pumping; 9 a – fiber optic, b – diaphragm, c – lens, d – plate with horizontal slit ; 10- gas mixture feeding.

Regarding to the diamond deposition conditions, a $H_2/CH_4/B_2H_6$ (99%: 1%: up to 100 ppm) gas mixture for a total flow of 300 sccm can be used. Besides, the B/C ratio in the mixture is presently equal to 16000 ppm (B_2H_6 flow-rate: 36 sccm). A Triax 550 spectrometer spectrograph, equipped with 1800/1200 grooves per millimeter gratings and with an Andor iStar-720D CCD detector, is implemented in the 400-700 nm wavelength range. The spectral resolution is close to 0.1 nm. The plasma emissions from a cylindrical volume (2 mm diameter) along the optical axis (*x* direction) are collected by a single fused silica lens which is coupled with a fused silica optical fiber and transmitted to the spectrograph.

Results and discussion

Emissions from the plasma are recorded at three vertical positions: z=1 mm (vicinity of the substrate-holder), z=6 mm and z=18 mm (plasma ball centre). Two emissions are specifically analysed: H* (H_α, λ=656 nm) and BH* (A-X, λ=432 nm). For these positions, a spatial scanning in the horizontal plan (*y* direction) is performed in order to record the signal Y(*y*) integrated along the *x* direction. Y(*y*) is them fitted by a second degree polynomial function in order to apply the Abel inversion with a narrower *y* step. The local emission function I(r) is them deduced while assuming that the H* defines the plasma glow frontier (intensity roughly zero) and that the plasma ball satisfies the circular symmetry (checked). According to the first reasonable assumption, we set a zero value for Y(*y*) at this position.

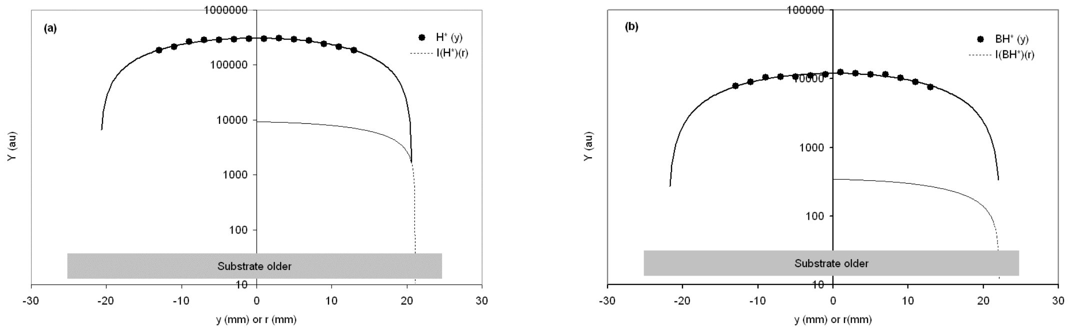

Fig. 2 Integrated emission profile Y(*y*) (circle) and corresponding fit curve (full line) and related inverse Abel transformation (dashed line) for H* (a) and BH* (b) for z=18 mm.

As a result, we can check the validity of the method applied to H* by confirming the spherical shape shown by local emissions (Fig. 2a). Applied to BH* emissions (Fig. 2b), the Abel method leads to a trend similar to that of H*, e.g. a maximum BH* density is observed at the r = 0 position. This conclusion is valid for all three z positions. Furthermore, BH* density (r=0) decreases from z=17 mm (plasma bulk) to the vicinity of the substrate older (z=1mm) like H* does as previously shown by Lombardie et al [1]. This preliminary work is the first result showing BH* spatial distribution in a plasma used for boron doped diamond growth and let us hope to get a better insight into the kinetics of this complex reactive medium.

References

[1] G. Lombardi, K. Hassouni, G. D. Stancu, L. Mechold, J. Röpcke, and A. Gicquel 2005 *Plasma Sources Sci. Technol.*, **14** 440

[2] M. Rayar, P. Veis, C. Foissac, P. Supiot and A. Gicquel 2006 *J. Phys. D: Appl. Phys.* **39** 2151

[3] H. R. Griem, *Plasma Spectroscopy* 1964 McGraw-Hill, New York