Influence of the gas flow on the microwave torch plasma flame structure

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The laser visualisation and flow velocity field measuring techniques (e.g. [1]) have become important for the diagnostics of plasmas [2]. In this paper we present results of the laser flow visualisation and Particle Image Velocimetry (PIV) measurement of the flow velocity field in a nitrogen or argon plasma flame generated by the microwave torch in ambient air. This investigation is important for improving the performance of microwave torch plasmas (MTPs), which are attractive for decomposition of gaseous pollutants. The microwave power delivered to the plasma was in the range of 100–300 W. The operating gas (nitrogen or argon) was blown through the microwave torch nozzle at a flow rate of 0.5–2 l/min. Al_2O_3 particles were added as a seed to the operating gas flow for the flow visualization and PIV measurement. The investigation showed that the MTP structure and the flow pattern depend on the kind of the operating gas (different patterns for nitrogen and argon), its velocity and microwave power. The obtained results are useful for optimizing the MTP.

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1 Introduction

Recently, various microwave torch plasmas (MTPs) were developed, either consisting solely of coaxial line components or fed from a waveguide [3, 4]. An MTP generator, based on the TIAGO concept disclosed by Moisan et al. [4], has proved attractive for decomposition of gaseous pollutants [5–7].

In this paper images of the laser flow visualization of the gas flow pattern in the plasma flame generated by the microwave torch are presented. Also results of the measurement of the flow velocity field in the MTP flame using Particle Image Velocimetry (PIV) are presented. This investigation is important for improving the performance of MTPs.

2 Experimental setup

The experimental setup used in this investigation consisted of a 2.45 GHz magnetron generator, MTP generator used in [7] for decomposition of gaseous pollutants, microwave power supplying and measuring system, gas supplying and flow control system, and PIV measuring equipment. The essential concept of the MTP generator is shown in Fig. 1. The torch structure is built in a modified WR 430

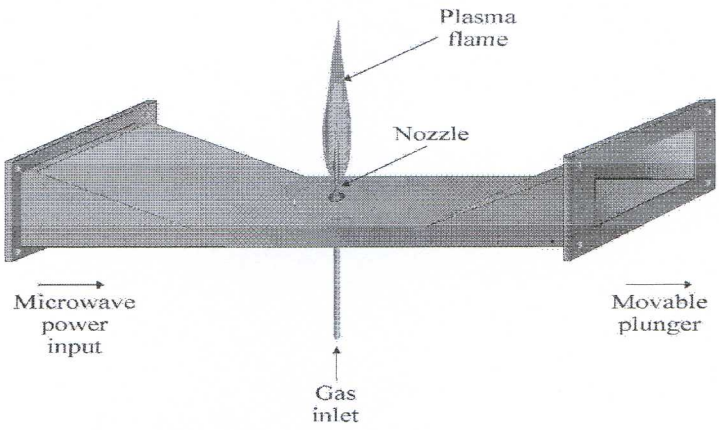

Fig. 1. The MTP generator used in the experiment.

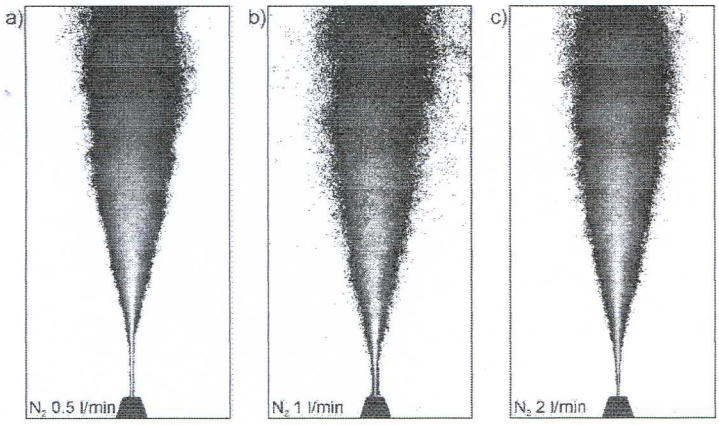

Fig. 2. Images of nitrogen flow structure at the torch nozzle without microwave discharge for different nitrogen flow rates: a) 0.5 l/min, b) 1 l/min, c) 2 l/min.

rectangular waveguide. A tube with a conical nozzle (inner diameter – 1 mm) is placed in a reduced–height section of the waveguide, perpendicularly to the its wide wall. At its gas–inlet side the nozzle tube is attached to the bottom wall of the reduced–height waveguide and protrudes through a circular gap in the opposite wall. The microwave power up to 300 W was fed directly through a waveguide from the magnetron generator at one end of the torch structure, while the opposite end is terminated with a movable plunger. The plasma was generated in the form of