NOVEL LOW POWER MICROWAVE PLASMA SOURCES AT ATMOSPHERIC PRESSURE

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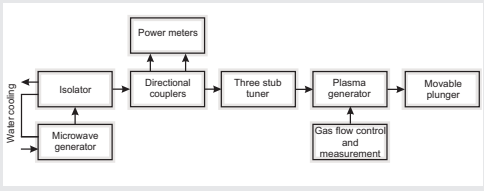
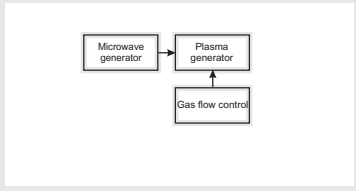
MOTIVATION

The aim of our work is to develope novel low power microwave plasma sources. Such devices are of high interest from industry point of view, e.g. for plastic and metal surface treatment. We propose three types of such plasma sources, namely waveguide slit plasma generator, multijet microwave plasma generator and microwave plasma sheet generator. All of them are of small dimensions and simple in design thus cheap in production. Plasma generated by them is of regular shape. They can be operated at atmospheric pressure what eliminates an expensive vacuum apparatus. Microwave operating frequency of 2.45 GHz and power lower than 500 W allows to use, in industrial setup, cheap commercial magnetrons such as that installed in microwave oven. Additionally they does not require the water cooling and could work without isolator.
All of presented here novel microwave plasma sources were designed, built and testes in our Centre for Plasma and Laser Engineering.



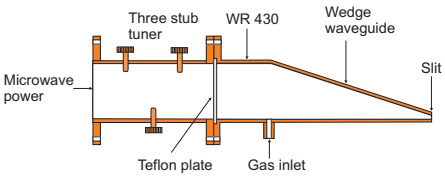
The diagram of the setup for experimental investigations of novel microwave plasma sources



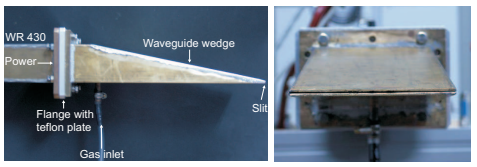
The diagram of the setup for industry applications

WAVEGUIDE SLIT PLASMA GENERATOR

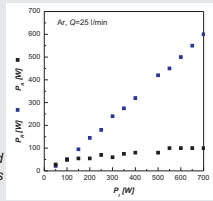
The new waveguide slit plasma generator is based on the WR 430 standard rectangular waveguide. Its sketch is presented below. It has the form of the wedge waveguide tipped with a slit of dimensions 1×54.6 mm. From microwave power input side the generator is terminated with a teflon plate which prevent flowing of the gas to the waveguide circuit. Generated in the waveguide slit plasma due to the gas flow leaves the waveguide region. Protruded plasma gives the possibility of contact with treatment material. For initiation the discharge the absorbed microwave power P_A, as low as 50 W, is required.



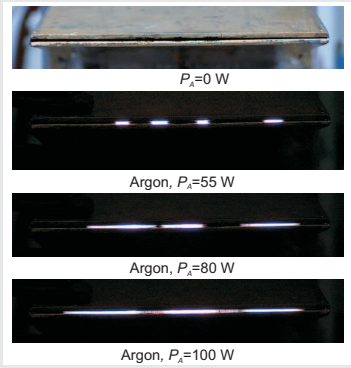
The sketch of the waveguide slit plasma generator



The photos of the waveguide slit plasma generator



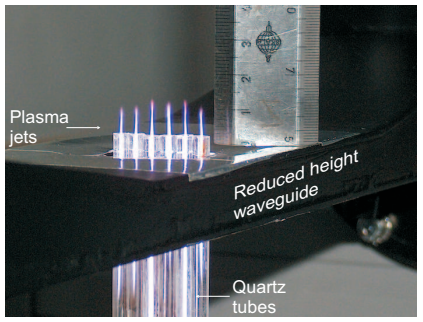
Reflected P_R at plasma generator input and absorbed P_A in the plasma microwave powers measured versus incident microwave power P_I



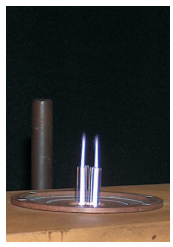
Waveguide slit argon plasma for different values of absorbed microwave power P_A. Gas flow rate Q=25 l/min.

MULTIJET PLASMA GENERATOR

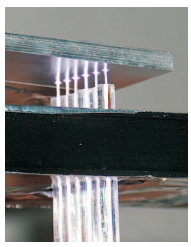
The idea of the multijet plasma generator is based on the surface wave sustained discharge in dielectric tube. In such a discharge the surface wave propagates along the interface between the plasma it creates and the dielectric tube enclosing the plasma. The wave traveling along the plasma column surface is continuously transferring a fraction of its power to the plasma it maintains. The column ends where the wave power is already too low to sustain the plasma. Ensuring appropriate gas flow rate the plasma exits out of the tube forming plasma jet. Changing the gas flow rate and position of the tube within the waveguide the length of the plasma jet can be changed. We accommodated a few quartz discharge tubes in one launching gap of the reduced height waveguide. We coupled six single tubes together, with a low loss dielectric glue, in a single file. The inner and outer diameters of each tube are 1 and 5 mm, respectively. Such small tube inner diameter prevents plasma filamentation.



Six plasma jets supplied from a reduced height waveguide. Microwave power P_I=300 W, argon flow rate Q=5 l/min.



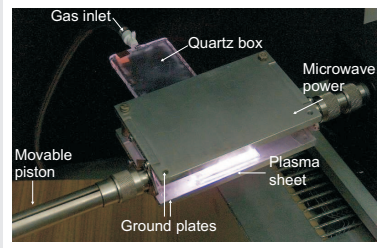
Two microwave plasma jets in a reduced height section of the WR 284 waveguide



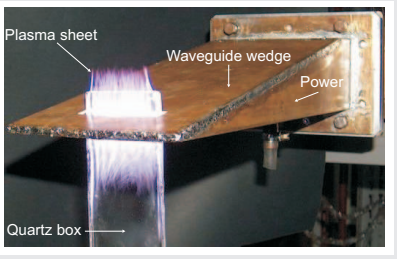
Six plasma jets, fed through waveguide, during metal plate treatment. Microwave power P_I=250 W, argon flow rate Q=25 l/min.

PLASMA SHEET GENERATOR

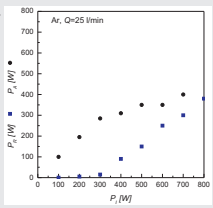
The main advantage of presented here microwave plasma sheet generator is a shape of generated plasma, namely sheet shape. It is convenient from surface treatment point of view, thus attractive for industry. The plasma is generated inside a quartz box through which the working gas flows. Because of the gas flow the plasma goes out of a box permitting the processing of the material's surface. The exemplary dimensions of the generated plasma sheet could be 50 mm of width and 1 mm of thickness for absorbed microwave power P_A=200 W and argon flow rate Q=5 l/min. Depending on the microwave power and gas flow rate the gas temperature of the generated plasma varies from 400°C to 800°C. Presented here plasma sheet generator can be supplied from a stripline, a waveguide or a wedge waveguide.



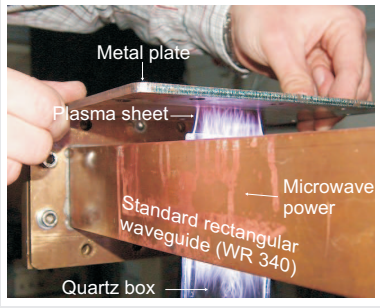
Stripline based device for generation of the microwave plasma sheet. Microwave power P_I=300 W, argon flow rate Q=5 l/min.



Plasma sheet generator supplied from a waveguide wedge. Microwave power P_I=300 W, argon flow rate Q=5 l/min.



Reflected P_R at plasma generator input and absorbed P_A in the plasma microwave powers measured versus incident microwave power P_I in the case of waveguide wedge based device



Plasma sheet, fed through waveguide, during metal plate treatment. Microwave power P_I=250 W, argon flow rate Q=25 l/min.