Apparatus complex for obtaining low-temperature microwave plasma at atmospheric pressure
9- 14 June 2019, Naples, Italy

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Abstract: A hardware complex was designed and manufactured to produce low-temperature and/or non-thermal microwave plasma at atmospheric pressure. Non-thermal plasmas are generated by a diversity of microwave discharges such as dielectric barrier discharges (DBD), atmospheric pressure plasma jet (APPJ) and atmospheric pressure Argon streamer plasma. The equipment includes three types of applicators, waveguide/coax splitter, cable assembly and water load.

Keywords: microwave plasma, non-thermal plasma, plasma technology.

1. Introduction

Traditional plasma generators, such as electric arc, high-frequency and microwave plasma torches produce plasma with operating temperatures from several thousand to tens of thousands of degrees, but according to the classification of physicists, such plasma also refers to low-temperature plasma. This subdivision is due to the importance of high-temperature plasma in the problem of controlled thermonuclear fusion. Over the past two decades, the scientific and technical community has made significant efforts to develop, maintain and use atmospheric non-thermal plasma (ANTP) in which ions and neutral components remain at or near room temperature [1]. This allows the use of such ANT plasma for low-temperature plasma chemistry and for the processing of heat-sensitive materials, including polymers and biological tissues. The growth and importance of the ANTP technology and its application has spread to a large number of areas, such as environmental engineering, aerospace engineering, biomedicine, textiles, food and agricultural technologies, analytical chemistry and several others [2].

The purpose of this work is to present a universal hardware complex, designed to generate both traditional low-temperature plasma and two types of ANTP in the R&D works on new materials and technologies, and also to intensify existing technological processes.

2. Design development

The hardware complex in the basic configuration consists of a microwave generator with HV power supply, a set of replaceable elements of the waveguide system, a water load, a 50 Ω cable assembly with N-connectors and one or several ANTP applicators (Fig. 1).

The basis of the presented hardware complex is a low-budget the 2.45 GHz magnetron microwave oscillator with a high-voltage power unit built on the magnetrons, transformers and capacitors used in microwave ovens for domestic and industrial use [3]. The output power of the microwave generator can be changed discretely, in the range from 0.5 to 3 kW, the number of stages (three or more) and a specific set of power levels can be established in agreement with the customer.

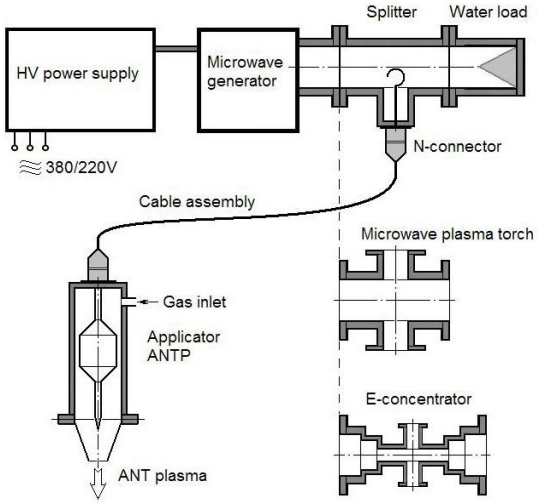

Fig. 1. Schematic diagram of components and blocks of the hardware complex.

The main elements of the waveguide system are made of stainless steel on the basis of a standard rectangular profile of 100×50×2 mm3, with WR-340 flanges size. In the basic configuration, the waveguide path is loaded onto the final resonant water load. Between the output of the microwave generator and the load, the waveguide path elements from the next set can be placed.

1. The microwave plasma torch on the main type H_{01} oscillations in the waveguide. Continuing our traditional principle of maximum use of the ready-made components, now we supply our microwave plasma systems with plasma torches, built on the basis of standard threaded stainless steel and brass fittings for metal pipes [4].

2. E-field concentrator of a step-by-step design or with a smooth change in the height of the waveguide - to increase the electric field strength in the microwave plasma torch placement zone. The narrowing of the waveguide can be symmetrical or one-sided.

3. An inductive-type splitter is a coupling loop located on a narrow wall of the waveguide. The design of the coupler allows you to change the communication value by rotating the loop plane, which is loaded on the N-type

coaxial connector. At the maximum coupling value, of about 14% of the microwave generator power branches off into the coaxial, while in the main waveguide the introduced reflections do not exceed 4%.

The payload (ANTP applicator) is connected to the splitter using a cable assembly that is a 50 Ω section of a flexible coaxial cable with N-type connectors at the ends. It is possible to combine a splitter and a microwave plasma torch in one node.

3. Results

Thus, a universal hardware complex of variable configuration for generation low-temperature microwave plasma at atmospheric pressure has been developed. It is designed for both laboratory and industrial applications. The general view of the complex is shown in Fig. 2.

Fig. 2. The general view of universal hardware complex for obtaining of low-temperature and ANT plasma.

The development of new elements for the hardware complex continues. In particular, experimental studies are being conducted on the development of sources of an ANTP based on a dielectric barrier microwave discharge in a coaxial and waveguide structure, as well as on applicators for studying the interaction of microwave plasma with various liquids. To expand the technical and technological capabilities, the hardware complex can be additionally equipped with a microwave circulator, a contactless mobile waveguide short-circuiting plunger and strip directional couplers to measure the incident and reflected waves.

4. References

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