NEW DISCHARGE TUBE WITH VIRTUAL CATHODE *

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Till this time known methods of the excitation of the discharge between electrodes are using either secondary or thermo emission of electrons by the cathode. Usually we speak about the self-maintained discharge. Lifetime of the cathode, that is shortened by the emission, limits in principle, the lifetime of the whole discharge tube. The discharge can, according to the present state of the art, be induced also by the inductive way. Arrangement for excitation of such discharge is rather expensive. The construction of the inductive excited discharge tube is considerably influenced by the necessity of the limitation of the losses in excitation magnetic circuits. Especially length of the discharge and pressure of the working gas are limited by the economic standpoints. Function of the discharge is always connected with unwanted electromegnetic radiation, whose restraint is expensive and represents limiting factor for arrangement of the discharge tube.

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1 Introduction

The above-mentioned disadvantages notably limits the new discharge tube with non-heated cathode with a working gas. Tube is formed by the anode and non-heated cathode among them is connected DC power supply. The matter of the new solution is in the fact that in the proximity of the cathode the discharge tube is modified to the form of inductive circuit, in that the ferromagnetic toroidal core with excitation winding is connected to the excitation generator. Inductive circuit passes to the part of the discharge tube with anode. Electric potential of the anode is higher than the electric potential of the cathode.

In advanced design will be set at least one recombinational electrode, with electric potential lower to anode electric potential, between anode and inductive circuit.

It is possible to say, that in principle the new discharge tube with virtual cathode was created. The self-maintained discharge is burning between anode and cathode, where the positive ions diffuse from the plasma formed by the inductive circuit to the cathode, while to the anode flow electrons, which induce excitation and ionization of atoms needed for the compensation of the ambipolar diffusion and recombination.

The advantage of the presented discharge tube [1] with non-heated (virtual) cathode is the the possibility of the excitation of the non-self-maintained discharge with minimum abrasion of the

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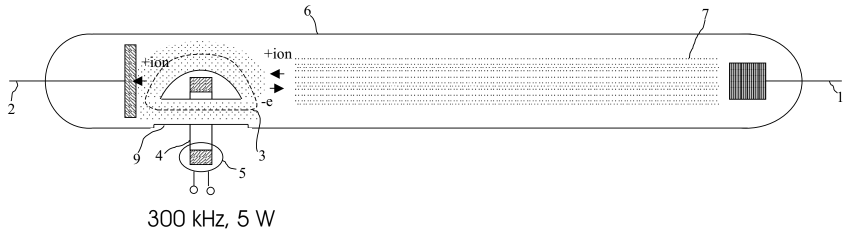

Fig. 1. Schematic view of the first variant of the new discharge tube.

cathode. Moreover, so-called cathode losses connected with emission of electrons is not present. Simultaneously is not discharge source of the unwanted electromagnetic field. Power supplied to the inductive circuit by the generator (aproximately 5 W including losses in magnetic core 2 W) is lower than power of the common induction discharge tube and construction of the generator with respect to the smaller demands to energetic efficiency is less expensive. Discharge then radiates less unwanted electromagnetic energy. The magnitude of the electric current flowing between the anode and cathode in the wide range of the voltage between anode and cathode does not depend on this voltage and it is possible to use direct voltage power supply.

2 New type of the discharge tube

Discharge tube from the Fig. 1 consists of electrically non-conducting cover formed by the tube 6 and an induction circuit 9 filled with a working gas or vapours. Inside of tube 6 is an anode 1 and a cathode 2. An electric potential of anode 1 is higher than an electric potential of a cathode 2. Through an inductive circuit 9, which is formed by the tube 6, a ferromagnetic core (toroid) 4 is cutted and is wrapped by an excitation winding 5. The alternating electric current from the generator flows thru this winding. Connection of the generator is not shown on the figure. In the induction circuit 9 exists electrodeless discharge 3. Positive ions are diffunding from the plasma of the discharge 3 to the cathode 2 and here they recombine. Neutral atoms or molecules (according to an used gas) move back from the cathode to the electrodeless discharge 3. The electrons from the plasma of the electrodeless discharge 3 are attracted and accelerated by the anode 1. They can excite or ionize neutral particles or they can recombine with the positive ions and then form a non- self-maintained discharge 7 in tube 6. At the end of the tube 6 the electrons are captured by the anode and the electric current flows between both electrodes.

3 Discussion

The authors constructed a different tube (Fig. 2), to obtain more information about the processes in surrounding of the cathode, and to find out about a possibility of getting a stronger electrical power between electrodes. The inductive circuit was more robust, formed a shape of a handle of a gardening tools, and was constructed on the end of a pipe of 50 mm in diameter. In proximity of the inductive circuit was a very short cylindrical cathode (diameter 45 mm) placed from the

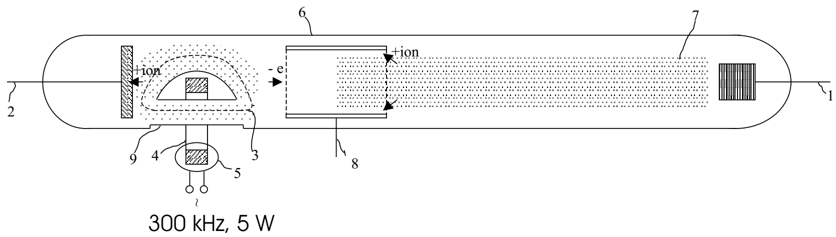

Fig. 2. Schematic view of the second variant of the discharge tube.

anode side verticaly to an axis of the tube. Next in a direction towards the anode another two electrodes were situated. The shape of the electrodes was a flat intercircle forming an angle of 90 degrees with the axis of the tube. In the beginning the tube was filled with krypton, later on with krypton and a mercury vapours. Electrical field between electrodes did not reach a plasma of an electrically excited discharge. A quality of this tube was almost the same like the original tube quality, the electrical power between electrodes was approximately 10 mA. The authors made experiments with draining of positive ions from the positive column by helping electrodes. If a voltage of these electrodes was decreasing towards the anodes, they started to disperse. Thanks to a low temperature of ions and a small surface of the electrodes the electrons started to attract each other and the light positive column was moved a few mm, but the power of the anode was not significantly changed. While a negative voltage of the helping electrodes towards anode reached more than 300 V, they began to be effected with a secondary emission. The helping recombination electrode can be useful in this case only if its surface is large. An expected speed of the ion diffusion for a unit of a surface of the helping electrode is lower than if using a cathode. It is not convenient nor effective to influence a speed of ions diffusion through an electrical field (by a voltage of an electrode). When the inductive discharge was placed outside the electrical field, a power between electrodes was not significantly decreased. The authors made experiments changing pressure of a working gas and its effect on a voltage and a apperance of the inductive discharge. It was not possible to keep krypton perfectly clean. The author revealed a strong negative effect of a dirt of krypton on a voltage on the discharge, which should be minimal. If a pressure is lower than 1 Pa, the produced light is bright and white in whole cross-section up to 150 mm far, except for shades behind barrier. If the pressure is higher than 150 Pa, the voltage on a discharge is significantly higher and authors know, that the pressure is over 200 Pa, a light of a positive column is pink and not nice. These discharge properties depend on current density too. Because of these results the authors think, that the most convenient for effect tubes is a pressure 50 Pa thanks to its brightness and colour of the light, and it is also convenient for use of a helping inductive discharge. Common tubes with a glow discharge can not be used for krypton of this pressure, because a dispersion of electrodes shortens their life too much.

4 Conclusion

These basic described experimental arrangements can be modified by the various ways:

Ignition of the induction discharge is possible with advantage facilitate AC electric field

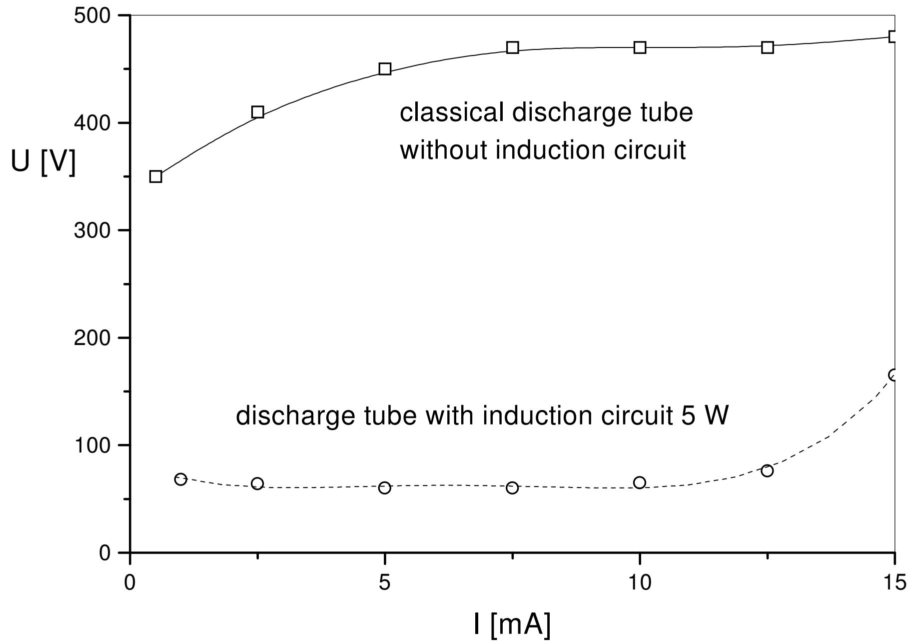

Fig. 3. Current-voltage characteristics of the low pressure discharge in Xe for both variants of the discharge.

between electrodes placed outside the induction circuit 9 and connected to the excitation or auxiliary winding of the ferromagnetic core 4.

If the discharge is excited in gas vapours, whose pressure is suitable to stabilize discharge for optimum working conditions, it is possible to make a series connection of the excitation winding and the magnetization winding of the stabilization ferromagnetic circuit which is designed so that AC magnetization gets its warming-up on so called Curie temperature. Ferromagnetic circuit should be located in so-called cool point of the discharge tube or e.g. so that it should be thermally connected with amalgam, if the discharge is working in mercury vapours. Used ferromagnetic material must have suitable Curie temperature.

The measured current-voltage characteristics of the new discharge are shown on Fig. 2, where the difference between the classical and new type of discharge is clearly shown. The first discharge tube is all right and it can be possibly used for verifying the experiments. It had been working for hundred hours without changing its quality. The cathode was rather dispersed, because it works on a different principle than a common glow discharge, its functionality was not affected. Barium does not seem polluted. The other discharge tube was donated to The Museum

Of The Light in Kralupy nad Vltavou and it is all right.

A self-maintained discharge is realized between an anode and a cathode. A current, which flows between them, is based on positive ions from a plasma, created by inductive in exciting in an inductive circle, diffunding to the cathode while electrons are flowing to the anode, which chaotic thermal motion causes an exit action of atoms and their ionisation needed for compensation of an ambipolar diffusion and recombination. The advantage of this solution is a possibility of exciting of a self-maintained glow discharge, which does not have a negative effect on a cathode, and does not cause a ”cathode loses” accompanied by an emission of electrons. The glow discharge does not cause a disturbing electromagnetic field. An inductive circuit is small and can be electrically shielded. A quality of an electrical power between the anode and the cathode is independent on a voltage between electrodes. Abrasion of the cathode caused by diffunding ions of a small energy is expected. Expected life of the discharge tube with a virtual cathode is incomparably longer than a life of a common discharge tube. As well a lower loses of the gas filling caused by a high energetical diffusion to a surface of components are expected.

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