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SYSTEM OF SPECTRALLY PURE HYDROGEN INFLOW FOR URAGAN-3M TORSATRON

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The used today system of hydrogen inflow into Uragan-3M torsatron (U-3M) vacuum chamber does not provide the needed purity of hydrogen during plasma experiments. In view of this, the simple construction of a diffusion Pd-membrane module system for spectrally pure hydrogen inflow was suggested and simulation experiments with experimental module were carried out. The tests on the special stand and in the U-3M vacuum vessel have showed such performances of the experimental module at T = 650°C and 1 at. hydrogen pressure: power for heating is ≈200 watt, hydrogen flow through membrane Q ≈ 1 Torr.l/s (specific hydrogen flow through membrane q ≈ 5.10^{-2} Torr.l/s.cm^2). The preliminary results obtained in this work have given the possibility to start the work design and construction of the system for inflow of spectrally pure hydrogen for the U-3M torsatron. Some details of this system are presented.

1. Introduction

The today system of hydrogen inflow into Uragan-3M torsatron (U-3M) vacuum chamber was made of hydrogen inlet from a high pressure vessel through automatic inlet system. However, even if the high purity hydrogen is contain in a high pressure vessel, such system does not provide the needed purity of hydrogen during plasma experiments (usually about a few percents of impurities) . So the value of the most experimental results comes lower and a new system for spectrally pure hydrogen inflow is needed. It is the main reason that in this work the new diffusion Pd-membrane module system for spectrally pure hydrogen inflow was suggested and the simulation experiments with the experimental module of such system were carried out.

2. Conception and design

The usually used for spectrally pure hydrogen inflow Pd-membranes have thickness about 1 mm (in order to provide the long life time and reliability). However, it is the difficult task to release the high required hydrogen flow Q (up to 5 Torr.l/s) for the U-3M by the use of such membranes (one must remember that $Q \sim d^{-1}$). In this work the utilizing of the rather thin Pd-membrane 0.1-0.25 mm thickness is suggested. And, in order to provide the required reliability, the special procedure of membrane heating and pumping of dissolved hydrogen is anticipated. This excludes the possibility of membrane disruption due to α-β transition in Pd. To exclude of heavy Pd-atom input into plasma volume it is suggested to use the TiN-coated palladium membranes.

The block-scheme of suggested system is shown in Fig.1. System comprises a block of diffusion membranes, which includes six diffusion modules, each of other has independent heating system. There are also the hydrogen pressure and temperature control systems, and pumping system to provide the functioning of diffusion modules. If it is needed the automatic systems can be used to keep the temperature and hydrogen pressure regime of diffusion module (pushed in the Fig.1). Also one can use the scheme with hydrogen generation block through the use of a palladium membrane and ethyl alcohol vapors. It was demonstrated earlier [1] that at an optimum ethyl alcohol vapor pressure and a membrane temperature such hydrogen generation scheme can provide hydrogen flow about 1 Torr.l/s for one Pd-membrane with surface area ≈ 20 cm^2 . But some additional investigations to be carried out to clarify the influence of carbon, releasing on the membrane surface due to ethyl vapor dehydration and thermal decomposition of ethylene, on the kinetics of hydrogen generation and penetration.

3. Experimental set-up

The experimental module (Fig.2) comprises a diffusion membrane (Pd-99.98 grade pipes 0.6 cm in diameter, 19 cm length, 0.025 cm in thickness), which was hermetically brazed at the one end. The outer surface of pipe was presented to the vacuum chamber, while the inner surface was in contact with hydrogen of high pressure vessel. The experimental modules under studies were also with the similar palladium pipes coated with a 3-μm-thick TiN layer. The membrane was heated by directly running the current through it. The temperature was controlled by chromel-Copel thermocouple located inside the pipe.

The tests of above mentioned diffusion module on the special stand, the scheme of which is similar to that described in [1] and in the U-3M vacuum vessel have showed such performances at T=650°C and 1 at. hydrogen pressure: power for heating is ≈200 watt, hydrogen flow through membrane Q ≈ 1 Torr.l/s (specific hydrogen flow through membrane q ≈ 5.10^{-2} Torr.l/s.cm^2). The H_2 pressure increase up to 2.10^{-5} Torr was observed in the U-3M vacuum chamber during such hydrogen inlet. Taking into account the net hydrogen pumping speed ~ 10^5 l/s in the U-3M vacuum chamber and ~ 5.10^{-4} Torr hydrogen pressure needed during experiments, the total number five/six of mentioned modules are necessary in order to get the required hydrogen flow 5 Torr.l/s into the U-3M vacuum chamber. The diffusion module performances can be

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improved by utilizing of more thin (up to 0.1 mm in U-3M) Pd-pipes with larger diameter as the membrane thickness d dependence of Q is $Q \sim d^{-1}$. The hydrogen pressure dependence of hydrogen flow through membrane is $Q \sim p^{0.5}$. More detail description of hydrogen behavior in Pd-membranes and TiN-coated Pd-membranes is given in [2,3].

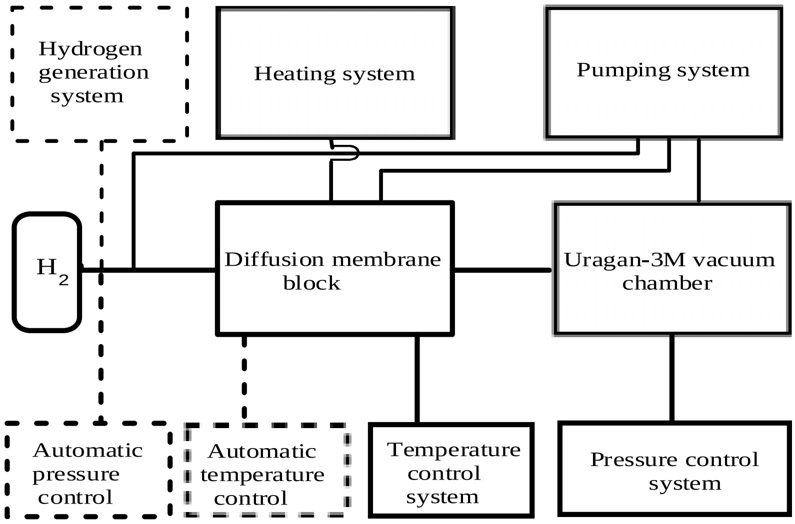

Fig. 1. Block-scheme of experimental set-up

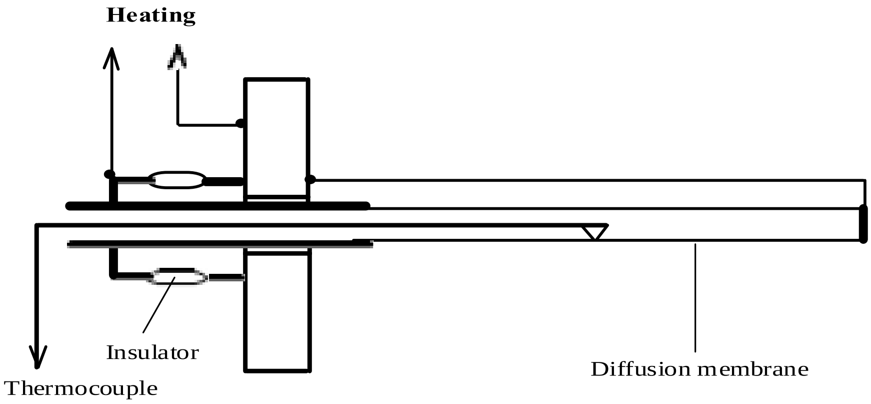

Fig.2. Experimental diffusion module

Conclusion

The preliminary results obtained in this work has shown the principal possibility for creation of a work system of spectrally pure hydrogen inflow for the U-3M torsatron . The nearest future steps in this direction will be the work design, construction and mounting of such system.

References

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