EFFECTS OF HELIUM ON THE SUPERPERMEATION OF THE GROUP Va METALS

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1. Introduction

A metal membrane of macroscopic thickness may be superpermeable to hydrogen particles whose energy (kinetic, internal or chemical) exceeds ~ 1 eV. Such a membrane can let through the energetic hydrogen almost like an opening of the same area, compress the permeating gas, and isolate it from a gas mixture: the superpermeability [1, 2]. The phenomenon is controlled by catalytic processes at the membrane surfaces and is conditioned by the state of the upstream surface, in particular, by the upstream potential barrier created by mono-atomic films of non-metallic elements such as O, C, S, etc.

During the last years, superpermeability was investigated for a number of metal – hydrogen systems, and a long-term stable membrane operation was demonstrated under various operational conditions. Still, there are a few subjects important for the practical applications of membranes requiring a further detailed study. The problem of the helium effect on the superpermeable membrane operation is among them.

As it is known, helium is expected to be one of the main gas impurities in various fusion devices. Although thermal helium atoms can hardly cause the change of the state of the membrane surface, its bombardment by fast neutral and ionized helium particles may result in the destruction of the surface film and lead to the decrease of the membrane permeation. Moreover, such an undesirable effect as blistering formation cannot be excluded too. For this reason study of the effects of helium on membrane operation appears to be rather interesting and important from the practical point of view.

2. Experimental

The present investigation was carried out with a tubular membrane of niobium (1 cm in diameter, 18 cm long, and 0.01 cm wall thickness) in the plasma-membrane test stand described in detail in Ref. 3 (see also M. Bacal, A.-M. Bruneteau and M.E. Notkin in these Proceedings).

The membrane is immersed into a uniform hydrogen plasma filling the input chamber of 44 cm diameter and 45 cm height. The plasma is generated by electric discharge.
between a set of sixteen hot tantalum cathode filaments (0.5 mm diameter, of a total area 30 cm²) located close to the chamber walls in a multicusp magnetic field and the chamber walls serving as an anode.

To provide the possibility to bias the membrane with respect to the plasma, it is electrically insulated with a ceramic break from the metallic vessel.

2.1. EXPERIMENTAL PROCEDURE

Two types of experiments were performed in the course of the present investigation. First, the experiments in which the membrane was under floating potential of about 3 V. Second, a bias voltage was applied to the membrane. The bias voltage varied over the range of 20 - 250 V, and, correspondingly, the membrane inlet surface was acted upon by accelerated hydrogen and helium ions of an energy up to 250 eV.

Switching on of filament heating or of the plasma discharge leads to the generation of energetic hydrogen particles. Those particles which are absorbed by the membrane, penetrate through it, and are released at its output side in molecular form. That results in an increase of the output pressure. After establishment of a steady state level of hydrogen permeation, helium is admitted into the input chamber of experimental setup, and the effects of helium are investigated over a wide range of membrane temperature, plasma parameters and helium content in the hydrogen / helium mixture.

3. Experiments with membrane at a floating potential in the presence of helium

3.1. THERMAL ATOM DRIVEN PERMEATION

The results of the experiment on the effects of helium on thermal hydrogen atom driven permeation through the superpermeable niobium membrane are presented in fig. 1.

![Graph showing effects of helium on thermal atom driven permeation](image-url)

*Figure 1. Effects of helium on thermal atom driven permeation*