Detection of helium-3 and tritium produced as a result of ion plasma saturation of titanium by deuterium

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Helium-3 and tritium have been detected in the mass spectra of gases produced as a result of the bombardment of titanium with deuterium ions. The presence of helium-3 and tritium may be the result of nuclear reactions due to ion plasma saturation of titanium by deuterium.

A low-temperature nuclear reaction of deuterium, in which helium-3 and tritium form due to an electrolytic saturation of palladium by deuterium, was recently reported for the first time.[1] The list of metals capable of stimulating such reactions due to an electrolysis of heavy water[1] or ion implantation of deuterium[1] so far is limited. If, however, titanium could be used as a substrate for deuterium implantation, then one of the more simple and experimentally accessible devices, which allows large surface areas of titanium to be effectively treated by bombarding them with intense deuterium ion fluxes with energies of several kiloelectron volts, may turn out to be an ordinary titanium magnetic-discharge pump.

We have accordingly carried out a mass-spectroscopic analysis of gaseous products formed during the operation of a NMD-0.63 pump in deuterium. This pump, which was used in a spectrometric apparatus,[2] can develop a residual gas pressure below 10^{-7} Pa by sputtering titanium in a gas plasma with a current of up to 1 A and a voltage of about 9 keV. The electrode arrangement in one of the six electrode units of this pump is shown in Fig. 1. An anode (*2*) is situated between two grounded cathodes (*1*) made of grade BT 1-0 sheet titanium. The anode consists of electrically connected cylindrical cells, to which a positive discharge voltage U is applied. The electrode assemblies are placed in a magnetic field, whose direction is shown by the arrow in Fig. 1. The electrons which are emitted as a result of a Penning discharge between the

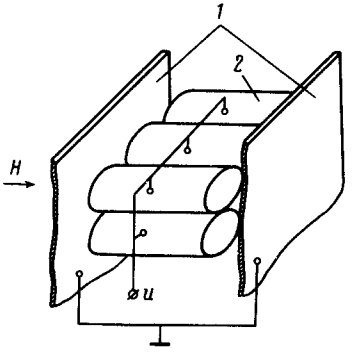

FIG. 1. Schematic diagram of the electrode assembly of the NMD-6.3 pump. *1*—Titanium cathodes; *2*—cylindrical anodes.

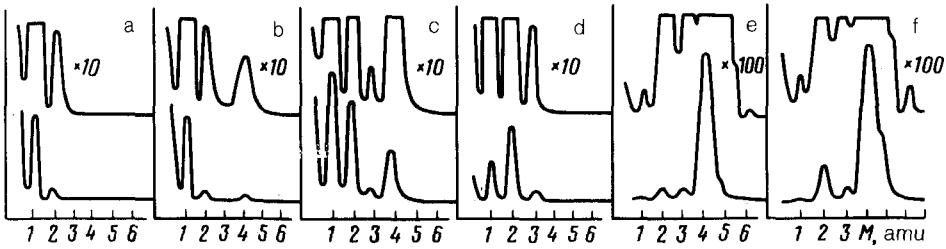

FIG. 2. Initial parts of the mass spectra of the residual gases at a pressure of 10^{-3} Pa 20 h after turning off the pump which was initially not treated with deuterium (a) and which was initially treated with deuterium for 6 h with a 0.2-mA discharge current (b) and with a 40-mA discharge current (c). The same parts of mass spectra at a pressure of 10^{-5} Pa, after turning on the pump (d) and during the treatment of a running pump with deuterium at a pressure of 3×10^{-4} Pa and a 23-mA current (e); 10^{-3} Pa, 40 mA (f).

anode and the cathodes oscillate in the discharge gap and ionize the residual gas. The positive ions of the residual gas produced in this manner bombard the titanium cathodes, causing sputtering of titanium which combines the chemically active gases as it precipitates on the anode and the pump housing. An important point here is that if the admitted gas is deuterium, the operation of the pump will cause the titanium cathodes, ~0.5 m^2 in total area, to be saturated with ion plasma as a result of an intense flux of ~9-keV deuterium ions. The titanium sputtering efficiency is low because of the small mass of the bombarding deuterium ions.

The inital parts of the mass spectra which we have obtained are shown in Fig. 2. We see in Fig. 2a that in the initial state (with the residual pressure of 10^{-3} Pa and the pump, which never held any deuterium, turned off) the residual gases contain hydrogen, without any traces of helium, tritium, or molecular deuterium. After a six-hour operation of the pump, during which time it was filled with deuterium to pressures of 3×10^{-6} Pa and 8×10^{-4} Pa, at which point the gas inflow was cut off and the chamber was pumped out to 8×10^{-7} Pa, the pump was shut off and held until a pressure of 10^{-3} Pa was reached. The residual-gas mass spectra corresponding to this process are shown in Figs. 2b and 2c, respectively. In addition to the atomic and molecular hydrogen peaks, these spectra contain deuterium which is a component of the peaks with the mass numbers $M=2$ and $M=4$. The nature of the peak with a mass number $M=3$ remains a mystery, since it could correspond to the $^1H_3$ and $^1H^2D$ molecules and/or to the ^{3}He reaction product (the presence of ^{3}T is unlikely since the $^3T_2$ peak is absent in both mass spectra).

Even after a lighter treatment (Fig. 2b), however, the ensuing short operation of the pump led to the appearance of a peak with a mass number $M=3$ and to the disappearance of the molecular-deuterium peak, $M=4$ (Fig. 2d). The pumping rate of the gas corresponding to $M=3$ was so low that upon further running of the pump this peak could be observed for some time (about 30 min) in the residual vacuum of 10^{-6} Pa or better. There is no molecular deuterium in the spectrum shown in Fig. 2d. The presence of $^1H^2D$ molecules is therefore unlikely. Furthermore, the production of

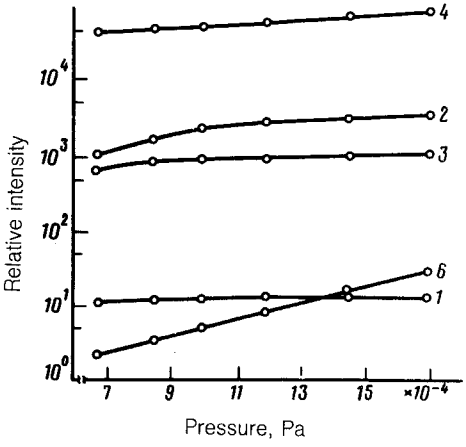

FIG. 3. The area under the peak of the mass spectrum vs the deuterium pressure. The figures give the mass numbers, expressed in amu.

a $^1H_3^+$ ion in a hydrogenous atmosphere has not been detected even at a relatively low pressure of 10^{-3} Pa. It is legitimate to assume, therefore, that the gas which is desorbed from the deuterium-treated titanium plates at the moment the pump is turned on and which is pumped at a realtively slow rate is helium-3, whose pumping rate is lower than that of hydrogen or deuterium by more than an order of magnitude.

Figures 2e and 2f show the results of an experimental study of the conditions under which tritium, another reaction product, appears in the spectra. It was established that molecular tritium ($M = 6$) is liberated most efficiently when the pump's operating current is greater than 20 mA, i.e., when the flow rate of deuterium which bombards the titanium is on the order of 10^{17} ions/s. The plot of this process as a function of deuterium pressure is shown in Fig. 3. We see that the $M = 6$ signal increases rapidly (the slope is 0.25). This signal increases much faster than the signals from the gases with other mass numbers. At relatively high pressures the fast increase in the intensity of the $M = 6$ peak may be due to the tritium impurity in the admitted deuterium or to the $^2D_3^+$ or $^1H_2\ ^2D_2^+$ ions which are produced as a result of the electron-collision-induced ionization of the gas. We found that the mass spectra of deuterium admitted into the turned-off pump contain the $M = 6$ peak. This signal becomes detectable, however, only at a deuterium pressure of 2.3×10^{-3} Pa or higher. Furthermore, the pressure-dependent rate of increase of its intensity is much lower than that shown in Fig. 3 (the slope is 0.07).

It would therefore be justifiable to conclude that a liberation of respectively helium-3 and molecular tritium, produced as a result of ion plasma bombardment of titanium with deuterium, has been detected in the spectra shown in Fig. 2, d–f. Our result could be experimentally pertinent in view of the possibility of cold-fusion reactions,[1] and the simplicity of the experimental technique makes our approach accessible to many researchers.

[1]Private communication of V. P. Seminozhenko.

[1]M. Fleischmann and S. Pons, J. Electroanal. Chem. **261**, 301 (1989).
[2]V. T. Cherepin *et al.*, Prib. Tekh. Eksp. **1**, 155 (1986).

Translated by S. J. Amoretty