

EFFECT OF PALLADIUM ALLOYING WITH GROUP III ELEMENTS ON ITS REACTION WITH HYDROGEN AND HYDROGEN PERMEABILITY OF MEMBRANES FOR HYDROGEN PURIFICATION

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Introduction

Palladium and palladium-based alloys exhibit an unique property, namely, the selective permeability with respect to hydrogen. This allows one to design chemical apparatuses for realization of technological processes using thin metallic partitions or membranes, which divide a chemical reactor into two zones that are connected only by hydrogen flow. Currently available industrial apparatuses for the hydrogen purification are intended for its finishing purification with respect to water vapour and use metallic membranes based on palladium-silver alloys. The use of such apparatuses in vapour-gas media containing organic products (carbon, hydro-carbons, carbon dioxide, etc.) abruptly decreases their efficiency because of the degradation technological properties of Pd-Ag alloys.

Results and discussion

Results of comprehensive investigation of properties of multicomponent alloys based on palladium alloyed with group III elements showed the high efficiency of membranes made of the alloys and intended for hydrogen purification and selection of hydrogen from gas mixtures.

Palladium-yttrium compositions alloyed with Group VIII metal are characterized by high manufacturing properties upon plastic working that allow us to prepare thin foils by cold rolling. Membranes made of these foils provide the operation ability of diffusion elements at temperatures from 100 to 650°C and pressure differential between reactor zones to 10 atm. The use of yttrium as an alloying element allowed us to suppress ($\alpha \rightarrow \beta$) phase transition at temperatures from 50 to 150°C that is typical of palladium-silver alloys and to increase the hydrogen permeability of membranes (see Table).

The alloying of palladium-yttrium alloys with ruthenium allowed us to stabilize the crystal structure of membrane alloys in the temperature range of operation of diffusion elements and, therefore, to decrease the specific consumption of materials and decrease the cost of working elements.

Conclusions

High-purity hydrogen of no less than 99.999% purity is necessary for preparation of metal hydrides and silicon in nanocrystalline state. Now, this problem can be solved only using diffusion membrane elements based on palladium alloys.

Table
Specific hydrogen permeability Q_{H_2} ($m^3/m^2 \cdot h \cdot MPa^{0.5}$) of palladium alloys at different temperatures

N	Alloy composition	Temperature, °C					
		350	400	450	500	550	600
1	Pd-6% Y	4.8	4.9	5.0	5.2	5.5	5.8
2	Pd-8% Y	3.3	3.8	4.0	4.1	4.2	4.3
3	Pd-10% Y	2.5	3.0	3.3	3.7	3.8	4.0
4	Pd-6%Y-0.5%Me	3.1	3.2	3.4	3.7	3.8	3.9
5	Pd-8%Y-0.5%Me	3.6	4.0	4.3	3.7	4.5	4.7
6	Pd-6%In-0.5%Ru	1.0	1.2	1.5	4.4	1.9	2.2
7	Pd-23% Ag	1.6	1.9	2.3	1.7	3.0	3.4