HYDROGEN SENSOR BASED ON WO_{3-x} NANOPARTICLES. ELECTRONIC AND ATOMIC STRUCTURE, ELECTROPHYSICAL CHARACTERISTICS

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Introduction

Nanopowders of refractory metal oxides are perspective materials for making new types of gas sensors. In the work electronic and atomic structure of nanodispersed tungsten oxides n-WO_{3-x} were investigated and electrophysical characteristics of a sensor on their basis were analyzed.

Results and discussion

Films of n-WO_{3-x} nanoparticles were synthesized by method of electrical explosion of conductors. The main purpose of the synthesis was formation of aliovalent states of metal ions in WO_{3-x} nanopowders to obtain necessary electrophysical characteristics.

By methods of XPS and TEM electronic and atomic structure of the films were explored.

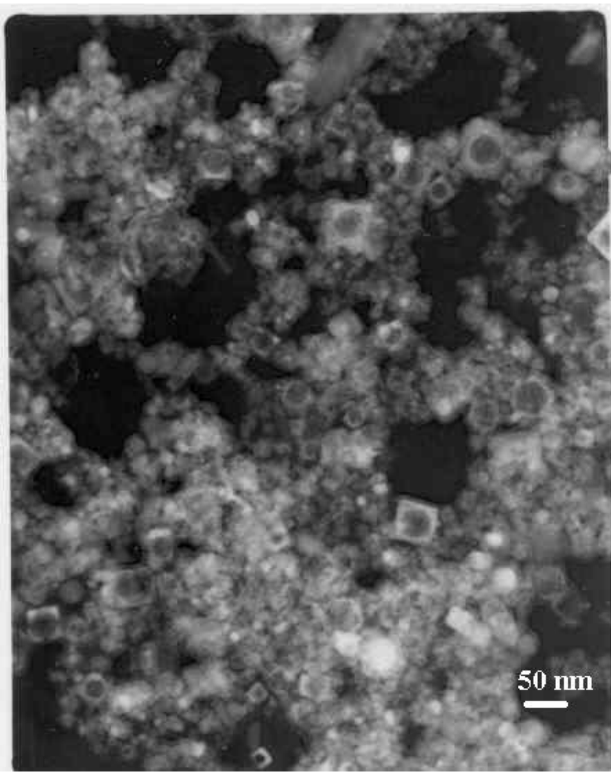

Fig.1
TEM micrograph of n-WO_{3-x} nanopowder.

Fig.1 shows the results of electronic microscopy studies by method of TEM. It was determined that diameter of nanoparticles in the initial powder varies between 5 and 45 nm. Nanoparticles consist of a spherical nucleus and a cubic shell.

At examination of a film surface by XPS method the number of nonequivalent states of ions in an oxide matrix and character of a chemical bond were determined. Fig.2 shows the results of decomposition of the XPS-spectrum on components.

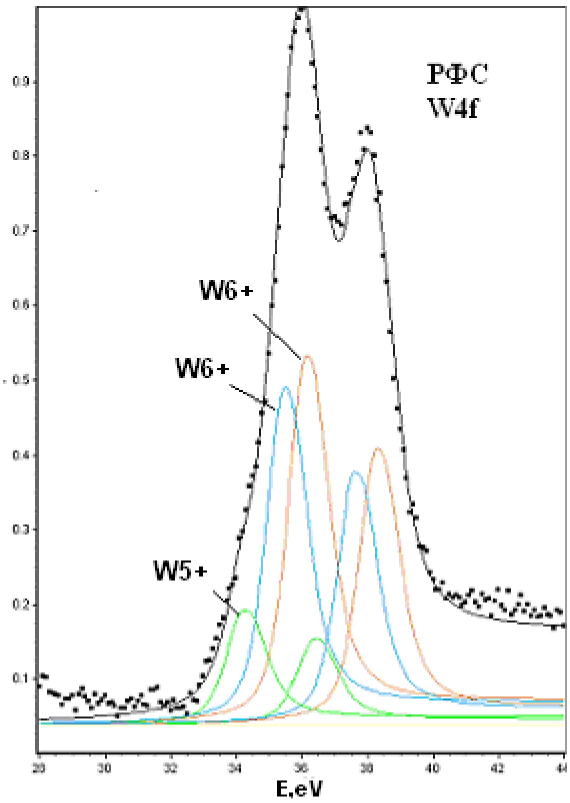

Fig.2
W4f components of XPS-spectrum components for WO_{3-x}-nanopowders .

Decomposition on components was carried out by a Gauss-Newton method in a mode of connected parameters for each pair, only intensity and bonding energy were varied, and such parameters as width a component on half of height, a ratio of Gauss-Lorentz distributions during decomposition of spectra were kept constant. The area the component was determined after subtraction of a background by method of Shirley. Received in such a way integral intensities are proportional to the contents of nonequivalent states of tungsten atoms on the films surface.

It was determined that the films have following consistence: W^{6+}-states $WO_3{\cdot}H_2O$ (45%), W^{6+}-states (41%) and W^{5+}-states (14%) WO_{3-x}. The contribution of nanophase in the initial powders is about 95%. Nanopowders have a crystal structure, types of lattices corresponds to WO_{3-x} oxides.

For measuring of sensing characteristics in gas medium an automated setting has been created on the basis of multimeter Keithley-2010 and the personal computer. The working chamber of the setting allows to carry out dosed lap joint of gases and to change measuring parameters from 77K up to 1273K.

Electrical resistance of films, measured by a 4x-dot method, in the range 293K-593K exponentially decreases with temperature growth. At temperature 363K the peak of sensor sensitivity to molecular hydrogen was recorded. Sensor response ($\Delta R/R$ x 100%) is 10 %. The choice of a differential circuit and usage of n-WO_{3-x} nanopowder with another ratio of aliovalent cations for the second sensor allow greatly reduce sensitivity of the sensor to water vapor.

Conclusions

Thus, formation of preset ratios between W^{6+}- and W^{5+}-cations in WO_{3-x} nanopowder causes the appearance of electrophysic characteristics which can be used at creating new types of gas sensors.