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Synthesis of Nanomaterials Based on Cadmium Sol-Gel Method for Carbon (II) Oxide Sensor

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Annotation: The influence of a dopant on the pattern of sol-gel synthesis of a gas-sensitive material based on tetraethoxysilane and metal oxides (Ti and Cd) in the presence of a template was studied. Analysis of the composition of the synthesized nanocomposites by DTA, X-ray diffraction and SEM methods showed that the elemental composition of the HCM corresponds to the composition of the components used in their preparation. To obtain highly porous films, heat treatment of HCM at 400-450 0C is recommended. Samples of thin films of the composition TEOS/75TiO2+CdO, which are gas sensitive to CO, were obtained. Selective sensors of carbon monoxide (II) were created based on the developed HCMs and optimal conditions were established that ensure the highest sensitivity and selectivity of the developed sensors.

Keywords: Nanomaterial, titanium oxide, cadmium oxide, template synthesis, gas-sensitive material, semiconductor sensor, carbon monoxide.

Introduction. Scientific research on the development and improvement of methods for analyzing the composition of atmospheric air and process gases deserves special attention in the world [1]. Carbon monoxide is one of the toxic and explosive components of atmospheric air [2]. In this regard, the development of semiconductor gas-sensitive materials and the creation on their basis of selective semiconductor sensors that provide the determination of carbon monoxide (II) in atmospheric air, process and exhaust gases is an important task [3]. The characteristics of semiconductor sensors depend on various factors, including the composition of gas-sensitive materials, which play an important role in ensuring high sensitivity and selectivity in determining the composition of a gas mixture [4].

The goal of the work is to develop selective semiconductor sensors for determining CO.

Experimental technique. In the template synthesis of gas-sensitive materials (GSM) semiconductor sensors (SPS) of carbon monoxide (II), TiO_2 and CdO are used as a dopant. The uniqueness of titanium and cadmium oxides as a dopant in the synthesis of HCMs for a semiconductor carbon monoxide sensor is caused by the combination of their physical and chemical properties [3-4].

The electrical conductivity of TiO_2 and CdO changes reversibly as a result of surface reactions occurring at 100-500 ^{0}C with the participation of chemisorbed oxygen and components of the gas mixture [5]. The advantages of titanium and cadmium oxides over other oxides are also their low cost, chemical resistance, and ease of manufacturing films based on their bases. Citric acid served as the structure-controlling agent in the process of synthesis of the HCM sensor. During the research, tetraethoxysilane (TEOS) $(C_2H_5O)_4Si$ os was used as the starting compounds for the synthesis of gas-sensitive materials. h, TU 2637-059-44493179-0. Double-distilled ethanol served as the TEOS solvent, and hydrofluoric acid was used as the catalyst for the sol-gel process. Experiments on the synthesis of HSM were carried out with the ratio of the starting components: TEOS: $:C_2H_5OH:H_2O:HF$=1:25:15:0,1. In the experiments, $TiCl_4$ and $CdC1_2$ were used as a source of TiO_2 and CdO.

The results obtained and their discussions. Template synthesis of porous silica materials in the presence of dapant was carried out according to the method given in [2-4]. To study the effect of the

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dopant on the stability of the film-forming solution, solutions of TEOS were prepared in purified ethanol at a molar ratio of TEOS:alcohol = 1:25. The resulting mixture was stirred for 2 hours, then left for 2 hours at room temperature. After this, a mixture of the corresponding salts dissolved in distilled water in the presence of an acid (catalyst) was added to the resulting solution with constant stirring. Metal oxides are widely used as gas-sensitive materials for chemical sensors [5].

During the experiments, the properties of gas-sensitive nanocomposite films synthesized based on titanium oxide and modifying metal oxides were studied. The following metal oxides were chosen as inorganic modifiers: ZrO_2, TiO_2, CdO, ZnO, In_2O_3, NiO, Mo_2O_3, Al_2O_3, SnO_2, which are characterized by high sensitivity to inorganic gases [5-7]. Modifying inorganic additives were introduced into the initial mixture through salts soluble in water and ethanol.

The developed semiconductor carbon monoxide sensors are in no way inferior in accuracy and reproducibility to well-known foreign analogues, while maintaining the following characteristics: rapidity, portability, ease of manufacture and operation. The value of the relative standard deviation (Sr) due to unmeasured components does not exceed 0.05. Changing the flow rate of the gas mixture in the studied interval (5 - 50 l/h) does not have a significant effect on the value of the sensor output signal. The output signal of the sensors also does not depend on their spatial location and tilt angles, which allows us to classify the developed sensors (according to GOST-13320-82) as independent.

Conclusion. Thus, the influence of the dopant on the pattern of sol-gel synthesis of gas-sensitive material based on tetraethoxysilane and metal oxides (Ti and Cd) in the presence of a template was studied. Analysis of the composition of the synthesized nanocomposites by DTA, X-ray diffraction and SEM methods showed that the elemental composition of the HCM corresponds to the composition of the components used in their preparation. To obtain highly porous films, heat treatment of HCM at 400-450 ^{0}C is recommended. Samples of thin films of the composition TEOS/75TiO_2+CdO, which are gas sensitive to CO, were obtained. Selective sensors of carbon monoxide (II) were created based on the developed HCMs and optimal conditions were established that ensure the highest sensitivity and selectivity of the developed sensors.

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