WO_3–graphene–Cu nanocomposites for CO, NO_2 and acetone gas sensors

Yulyan Haiduk[1], Alexander Khort[2, 3], Vasilina Lapitskaya[4], Tatyana Kuznetsova[4], Dmitry Moskovskikh [3], Alexander Savitsky[1], Natalia Lapchuk[1], Maksim Makhavikou[1], Vladimir Pankov[1]

[1] Belarusian State University, Niezaleznasti av. 4, 220030, Minsk, Belarus

[2] KTH, Royal Institute of Technology, Drottning Kristinas vag 51, SE-100 44 Stockholm, Sweden

[3] Center of Functional Nano-Ceramics, National University of Science and Technology "MISIS", Lenin av. 4, 119049 Moscow, Russia

[4] A. V. Luikov Heat and Mass Transfer Institute, National Academy of Sciences of Belarus, Minsk 220072, Belarus

Abstract

The control of indoor air quality and the detection of toxic gases and volatile organic compounds are important tasks for improving life and work conditions, and are highly demanded in a variety of industrial, agricultural and environmental applications. This requires the development of special gas sensing materials with a high sensing response to a variety of gases of a different chemical nature. Herein we report a study on the synthesis, characterization and investigation of the gas sensing properties of WO_3 -graphene–Cu composite nanomaterials. The nanomaterials have a closely interconnected defective structure with developed surfaces and are characterized by an enhanced sensing response to CO, NO_2 and acetone. The composite nanomaterials with WO_3 crystallite sizes of 13–17 nm were synthesized by a modified sol–gel method, where pre-synthesized graphene@Cu nanopowder, obtained by the solution combustion method, was added into an H_2WO_4 gel before the xerogel formation stage. The graphene@Cu flakes played the role of the centers of WO_3 crystallite nucleation, leading to the formation of mutually interconnected crystalline structures. The graphene@Cu composite tends to accumulate on the tungsten oxide surfaces, causing the formation of structural defects, influencing the surface energy state and concentration of free electrons. The concentration of defects decreases with the increase of graphene@Cu from 1 to 4 wt%, which also affects the gas sensing properties of the WO_3-graphene@Cu composites. The highest sensing response to CO and acetone of 19.7 and 21.4, respectively, were detected for the composite with 1 wt% of graphene@Cu. The composite with 2 wt.% of graphene@Cu additive showed the highest sensing response to NO_2.

Graphical abstract