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Abstract PhD thesis

This doctoral dissertation is devoted to the development and investigation of a new technology for fabricating advanced piezotronic sensors based on hybrid nanocomposites containing antimony iodide sulfide (SbSI) nanowires embedded in a polymer matrix. The primary goal of this work was not only to create materials with high application potential, but also to develop a novel research methodology enabling the unambiguous separation of piezotronic phenomena from the co-occurring piezoelectric and piezoresistive effects in complex multiphase systems. To achieve these research goals, a series of hybrid nanomaterials were synthesized using a sonochemical process. Various additional components were incorporated into the SbSI nanowire structure: graphite, graphene, titanium dioxide (TiO_2), and molybdenum disulfide (MoS_2). The next key step was to develop a method for fabricating nanocomposites in the form of flexible films using a photocurable resin. By using UV polymerization (405 nm), I was able to obtain composites with complex shapes that can be freely formed, paving the way for their use in modern wearable electronics and soft robotics. A comprehensive structural and electrical characterization of the obtained materials was conducted in this work. Using TEM, SEM, and SAED techniques, the correct morphology and crystallinity of the produced nanostructures were confirmed. Spectroscopic analyses (Raman, UV-Vis) allowed for the determination of the energy gap (E_g) and the Urbach energy (E_u). The most important achievement of this work was the development and verification of a methodology for separating piezoresistive signals. Piezoelectric measurements verified the absence of the piezoresistive effect. Current-voltage measurements at various pressure ranges proved the presence of a piezotronic phenomenon in the composite. It was demonstrated that the induced piezopotential at the phase junctions is responsible for the main response of the sensor under static loading. In summary, the work demonstrated that the developed hybrid nanocomposite fabrication technology enables the creation of repeatable, flexible, and shapeable sensors with unique piezotronic properties. The developed research tools represent a significant contribution to the development of the piezotronics field, offering a solution to the problem of signal masking in heterogeneous nanostructured systems.

Keywords: Piezotronics, printed electronics, piezoelectric effect, sensors, additive technologies, nanocomposites

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