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FUNCTIONALIZATION OF GRAPHENE AND ITS IMPACT TO SENSOR ABILITIES

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Due to their high sensitivity and stability, solid state ceramic materials have been widely used as gas sensors [1-2]. Carbon nanotubes and graphene are a new generation of gas sensor materials that are free from metal oxides. Almost all the interfaces of carbon nanotubes, graphene oxides, and graphene are exposed, and thus these materials exhibit high sensitivity to their surroundings [3]. Inherent defects, boundaries, and the introduction of structural defects are necessary to endow graphene with p- or n-type semiconducting properties.

We demonstrate the distinction of piezoresistive and chemiresistive graphene-based gas sensors and extremely high piezoresistive properties of polycrystalline graphene. Graphene materials with different numbers of layers were first intentionally prepared in this study, referred to as graphene-based sensors (GBSs), from two-layer graphene to multilayer graphene. These GBSs were then used to demonstrate the gas sensing of H_2, CO_2, NH_3, and He associated with piezoresistance and chemiresistive properties. The distinction of resistance changes by physical adsorption, chemisorption, and piezoresistance, as well as chemical structure changes of graphene before and after NH_3 gas injection were exhibited to gain a fundamental understanding of relationship between graphene structure changes and gas sensing with various gas insertion [4].

The GBSs synthesized by 80% and 100% CH_4 have piezoresistive properties evaluated using He gas. The GBSs synthesized by 80% and 100% CH_4 here had 100 and more than 300 graphene layers, respectively. The resistance responses by piezoresistance were 3–6% at ambient pressures, which were considerably higher than the preceding reports. Considerable changes in the sheet resistance with hysteresis by NH_3 injection were observed for the GBS synthesized by 40% CH_4 (trilayer and p-type semiconductor), whereas the GBS synthesized by 80% CH_4 (100 graphene layers and n-type semiconductor) exhibited relatively small and negative sheet resistance changes without any hysteresis. The hysteresis of the sheet resistance on GBS of 40% CH_4 is a result of NH_3 chemisorption, although the chemisorbed NH_3 was perfectly released by evacuation at 360 K. In this work demonstrated hetero atom doping by a dry method using plasma irradiation and evaluate its functionalization with structure and electrical resistance changes by plasma irradiation in O_2, H_2, Ar, N_2 gases. In addition, NH_3 gas sensing on functionalized graphene was evaluated using four-probe electrical measurements at 273 K, 300 K and 327 K. The initial graphene was high-quality bilayer graphene. The findings on the changes in sheet resistance of graphene by physical adsorption, chemisorption, and piezoresistance shed light on opportunities for the further development of gas sensors using graphene and its related materials.

REFERENCES

[1]. H. C. Mu, Z. Q. Zhang, X. J. Zhao, F. Liu, K. K. Wang and H. F. Xie, Appl. Phys. Lett., 2014, 105, 033107
[2]. N. Barsan, D. Koziej and U. Weimar, Sens. Actuator B-Chem., 2007, 121, 18-35
[3]. G. Lu, S. Park, K. Yu, R. S. Ruoff, L. E. Ocola, D. Rosenmann and J. Chen, ACS Nano, 2011, 5, 1154-1164
[4]. H. Kitayama, M. C. Ekayev, and O.Tomonori, Piezoresistive and chemiresistive gas sensing by metal-free graphene layers. Phys. Chem. Chem. Phys. vol. 22., no. 5, pp. 3089-3096, 2020