Hydrogen gas detection of gold nanoparticles on self-activated graphene layers

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Abstract:

Graphene is a leading candidate for next-generation gas sensing applications because of various advantages such as high sensitivity at room temperature, transparency, and flexibility. However, poor selectivity, and sluggish sensing behavior at room temperature are major drawbacks for practical use of graphene-based materials. To overcome the disadvantages, many kinds of noble metals are decorated on graphene surfaces. Here, we present room temperature hydrogen detection of Au nanoparticles deposited on self-activated graphene. The Au decorated graphene sensors with self-activation exhibit enhanced gas sensing properties such as rapid response, full recovery, and high selectivity. We discovered improvement in H_2 detection which has never been reported for Au decoration on any materials. The hydrogen sensing mechanism of Au nanoparticles on self-activated graphene is investigated by density-functional theory calculations. This discovery of a new functionality in the existing material broadens the possibility of metal nanoparticle/graphene heterostructures for diverse research areas.

Key words: Graphene, Gas sensor, Gold nanoparticles, Self-activation, Flexible, Hydrogenation, DFT calculations.

Result & Discussion

Gold as bulk metal is well known for the least active towards atoms and molecules. On the other hand, gold nanoparticles smaller than 10 nm have exhibited great potential for various research fields such as selective oxidation and hydrogenation by the gold catalytic effect. Although palladium and platinum catalysts have been mainly explored for hydrogen chemisorption, gold nanoparticles supported on metal oxide also have shown great potential for chemisorption of hydrogen molecules in recent studies. For these reasons, studies on interactions between gold nanoparticles and hydrogen molecules are attracting enormous attention in many research fields.

Graphene is a two-dimensional (2-D) material which has attracted significant research interest owing to its remarkable properties such as tremendous thermal and electrical conductivity, flexibility, transparency, and atomically thin structure. Due to these remarkable merits, studies on graphene for varied applications have become active from few years ago. Furthermore, since gas molecules are easily adsorbed on graphene, graphene is considered as a promising material for gas sensors.

In this work, we report hydrogen gas detection of gold nanoparticles on graphene layers which are self-activated by applied bias voltage from 1 to 60 V. Graphene used for the device is prepared by chemical vapor deposition method. Since graphene is a 2-D material, sensing area and electrodes composed of graphene can be defined by facile lithography processes. Gold nanoparticles are deposited by e-beam evaporator. The responses of the gas sensor to target gases such as H_2, CH_3COCH_3, and NO_2

DOI 10.5162/IMCS2018/P2GS.7

have been measured with varying input bias voltages at room temperature.

Our results show hydrogen gas detection of gold nanoparticles supported on graphene layers at room temperature. Also, the results open a potential of noble metal/graphene heterostructures for further studies.

References

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