Materials Science & Engineering Program

The Ph.D. Dissertation Defense of Chung Hee Moon

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Title: Investigation of bio-directed assembly of metal oxide and metal nanomaterials for chemiresistive gas sensors

With increasing development in nanotechnology, approaches for synthesis of nanomaterials with control over dimensions, grain size and crystallinity for various device applications is highly demanded. In this talk, bio-directed approaches for hierarchical assembly of metal and metal oxide nanostructures and its promise for chemiresistive gas sensors will be presented.

Biological building blocks such as amino acids direct assembly of intricate structures from nano- to macro -scale within the living system. Such ability of biological molecules have gained scientific interest to meet nanofabrication challenges and demands. A 1 µm long, filamentous M13 bacteriophage, in particular, is a promising biological molecule for synthesis of one-dimensional inorganic nanostructures. The genetic information can be easily manipulated to display specific peptide sequences on the M13 bacteriophage outer protein coats and has been involved in combinatorial phage display technology to identify inorganic specific peptide sequences. Furthermore, various inorganic nanomaterials have been synthesized by the M13 bacteriophage and its protein components. With our daily exposure to hazardous gases such as H_2S, H_2, CO, and NH_3, gas sensors with high sensitivity, low detection limit, low power consumption and miniature size for mobile and continuous monitoring are in demand. Nanoscale chemiresistive gas sensors have a relatively simple configuration and can be used for sensitive monitoring of gas levels with low power consumption. The large surface area to volume ratio provides increased adsorption sites for sensor-analyte interactions and the short diffusion length allows a rapid resistance change with exposure to low gas concentrations.

In this work, a novel platform for metal-based H_2S and H_2 chemiresistive gas sensors has been designed based on a gold-binding bacteriophage template. Continuous nanocrystalline gold chains assembled on the M13 bacteriophage backbone displayed high sensitivity and low lowest detection limit for H_2S sensing. The carboxyl and amine functional groups on the template with an affinity for sulfur added to device sensitivity. The same platform was also adapted for hybrid gold-palladium nanopeapod sensors for H_2 sensing. The sensor showed high response to low H_2 concentrations at ambient conditions. Moreover, bio-directed ZnO synthesis from M13 bacteriophage protein coats and peptide components were explored. Materials characterization revealed peptide concentration dependent morphology, crystallinity, and optical property tuning. This work demonstrates the promise of bio-directed nanofabrication for sensitive chemiresistive gas sensors.

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