Nanostructured Interfacial Materials for Piezoelectric and Chemiresistor Sensors

Li Han,[1] Jason Kneller,[1] Sandra Chun,[1] Jin Luo[1] and Chuan-Jian Zhong[1]

[1]State University of New York at Binghamton
Department of Chemistry
Binghamton, NY 13902
USA

While a large variety of transducer platforms are available for sensor technologies from commercial and research laboratory products, the development of advanced interfacial materials as sensor probe materials remains a challenging area of research. Nanostructured materials have recently emerged as an attractive candidate of interfacial probe materials, which have attracted tremendous interest because of their potential applications in microelectronics, catalysis, molecular recognition, and chemical/biological sensors. Inspired by intriguing attributes of core-shell type of nanoparticles in terms of fine-tunable capabilities in size, composition and surface properties, this work explores monolayer-encapsulated metal nanoparticles as building blocks for assembling nanostructured thin films towards chemically-responsive interfacial materials. Metallic (e.g., Au and alloy) and semiconductor (e.g., TiO2) nanoparticles of different core sizes (1 20 nm) and alkyl thiol linkers of different functionalities were studied as a model system. Such a system involves interparticle linkages via inter-core or inter-shell covalent bonding or non-covalent hydrogen-bonding. The nanostructured materials were shown to exhibit interesting molecular recognition and catalytic properties for both gas- and liquid-phase analytes. By coupling sensor array measurements with both piezoelectric and chemiresistor devices, the correlation of interfacial molecular interactions with electronic and mass loading properties at the nanostructured materials is investigated. Responses of high sensitivity and selectivity to volatile organic compounds and toxic gases have been demonstrated. The molecular interactions and reactivities at these nanostructured films are dependent on the core size of the nanoparticles and the chemical nature of the linking molecules. The implications of these findings to the design and fabrication of nanostructured materials as highly responsive interfacial chemical and biological probes, particularly in sensor array applications, by manipulating size, composition and surface structures, will be discussed.