Available online at www.scholarsresearchlibrary.com

Extended Abstract

Archives of Physics Research, 2017, 08 (4)
(https://www.scholarsresearchlibrary.com/journals/archives-of-physics-research/)

ISSN 0976-0970
CODEN (USA): APRRC7

Electrochemical surface modification of metal oxides for security applications and healthcare

Vardan Galstyan

University of Brescia, Italy

E-mail: vardan.galstyan@unibs.it

Combining two materials in a nanoscale level can create a composite with new functionalities and improvements in their physical and chemical properties. Here we present a high-throughput approach to produce a nanocomposite consisting of metal nanoparticles and semiconductor oxide nanostructures. Volmer-Weber growth, though unfavorable for thin films, promotes nucleation of dense and isolated metal nanoparticles on crystalline oxide nanostructures, resulting in new material properties. We demonstrate such a growth of Au nanoparticles on SnO2 nanostructures and a remarkable sensitivity of the nanocomposite for detecting traces of analytes in surface enhanced Raman spectroscopy. Au nanoparticles with tunable size enable us to modify surface wettability and convert hydrophilic oxide surfaces into super-hydrophobic with contact angles over 150°. We also find that charge injection through electron beam exposure shows the same effect as photo-induced charge separation, providing an extra Raman enhancement up to an order of magnitude. Metal nanoparticles or nanostructures can interact with the electromagnetic field at optical frequencies. A unique physical property in these nanoparticles is the strong field enhancement associated with localized plasmon excitation, which inspires development of novel devices in applications such as energy harvesting, chemical, and biological sensing. Among them, surface enhanced Raman spectroscopy (SERS) is an analytical technique with high sensitivity that enables the detection of chemical or biological analytes in trace amount far below the limit of the conventional Raman spectroscopy. The enhancement of electromagnetic fields amplifies Raman scattering signals of analytes adsorbed on rough metal surfaces, especially on the rough surfaces generated by noble metal nanostructures. The excitation of localized surface plasmon resonances (LSPRs) in the noble metals is generally considered as the main mechanism of SERS. Statement of the Problem: Chemical sensors have received great attention for the fabrication of small-size and mobile gas sensing. Noble metal nanoparticles typically exhibit SERS enhancement at sharp edges or gaps between metallic protrusions, called hot spots. devices for the environmental monitoring and clinical diagnostic. One-dimensional metal oxide nanomaterials are very promising structures for the application in chemical gas sensing. However, the sensing performance of these materials needs to be improved for the manufacturing of sensing systems with the high sensitivity, selectivity and stability. Herein, we report the synthesis of highly ordered titania nanotubes and the modification of their structure and surface for the chemical sensing applications.

Methodology & Theoretical Orientation: Well-ordered titania nanotube arrays were prepared by electrochemical anodization. The anodization process was performed in the electrochemical cell with the two-electrode system. Preparation of titania nanotubes by means of electrochemical anodization is anodic formation of nanotubes by oxidation and etching of metallic titanium films. Pt foil was used as a counter electrode. The anodization was carried out by potentiostatic mode at room temperature. This method allows direct growth of the titania nanotubes on different type of substrates and the modification of their surface structure at room temperature. The morphological, structural and elemental analyses of the obtained samples were performed. The sensing properties of the materials were tested towards different, explosive and toxic gases.

Findings: Pure and doped nanotubes have been obtained by the modification of anodization parameters. Our studies have shown that the engineering of the band gap and the functionalization of the surface structure of titania enhanced its gas sensing performance.

Conclusion & Significance: Investigations have shown that the response and the selectivity of titania nanotubes are improving depending on the modification of their composition and their functionalization. Meanwhile, the developed method is promising for the fabrication of high performance and small size chemical gas sensors. Tin oxide is a versatile optical and electrical material that has a broad range of applications in sensing, energy storage, and harvesting applications. There are various methods to synthesize SnO2 nanostructures. Among them, chemical vapor deposition (CVD) offers many options for customizing precursors.

Electrochemical sensors have drawn significant attention over the last couple of decades because of their ability to improve detection of organic and inorganic analytes found in the field of biotechnology, environmental sciences, medicine, and food quality control. This personal account summarizes the state-of-art research carried out in the construction and evaluation of nanostructured metal oxides and zeolite based electrochemical sensors. Metal oxides and zeolite-based nanomaterials have many unique and extraordinary properties such as tunable redox activity, surface functionalization ability, optimum conductivity, large surface area, biocompatibility and so forth. At last, the current advances in electrochemical sensor applications of metal oxides, zeolite-based nanomaterials, and their nanocomposites are described for the single and simultaneous determination of organic & inorganic contaminants present in water bodies, physiological bio-molecules present in human blood & urine samples, and organic contaminants present in food materials.

Bottom Note: *This work is partly presented at 3rd International Conference on Electrochemistry July 10-11, 2017, Berlin, Germany*