Design of Highly Selective 2-D Plasmonic Hydrogen Sensors by Tunable Porous Metal Oxide Layers

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Hydrogen economy is a zero-carbon emission economic model that encopasses various subtopics such as hydrogen storage, production, utilization, and detection, with hydrogen being the main energy carrier. This model holds great potential for our future due to several characteristics: the ability to produce hydrogen using renewable energy sources, three times higher energy density compared to fossil fuels (128 MJ/kg), and the production of water as a by product when used in fuel cells. However, hydrogen is an explosive gas when its concentration exceeds 4% in the air. Therefore, hydrogen sensors play a critical role in ensuring the safe use of hydrogen.

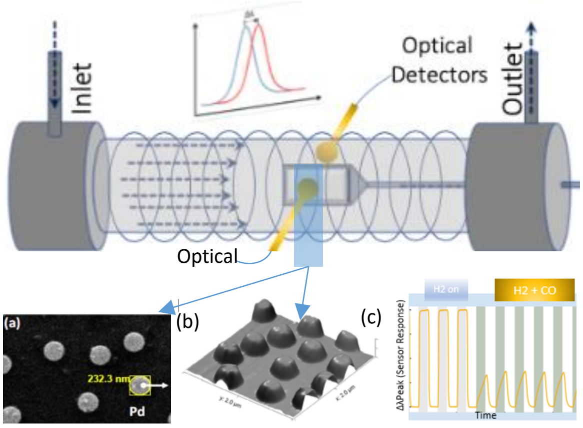

Figure 1. Reactor geometry and measurement principle. (a) SEM image of Pd nanodiscs, (b) AFM image of Pd nanodiscs, (c) plasmonic readouts of Pd nanodiscs on H_2 and H_2+CO environments.

Palladium-based plasmonic hydrogen sensors have gained attention in recent years due to their fast response times even at low hydrogen concentrations. Although they exhibit exellent response time due to intreaction betweem palladium and hydrogen at room temperature and strong plasmonic properties at nano scale, they have some drawbacks. Many studies have done to overcome its disadvantages. Hysteresis formation during hydrogen absorbtion and desorption, sensor deactivation because CO, are significant challenges that need to be overcome for selective and durable usage of the sensors. Binary and ternary Pd alloys, such as PdAu, PdCu and PdAuCu, formed in different concentrations, have been successful in suppressing hysteresis during hydrogen absorption and desorption[1]. The most notable study on sensor deactivation and cross-sensitivity has been conducted using polymeric membranes such as PMMA and PTFE[2]. Althoug the prapered membranes have shown selectivity, particularly in terms of deactivation, hydrogen sensors are devices that need to operate for extended periods in diverse environments. However, polymeric membranes are not resistant to high temperatures and corrosive enviroments.

The aim of our study is to adress sensor deactivation and cross-sensivity by obtaining a selective structure through the fabrication of mesoporous metal oxide (SiO_2) thin film coatings on Pd nanodisks produced via Hole Mask Colloidal Litography (HCL)[3]. The aim of our study is to adress sensor deactivation and cross-sensivity by obtaining a selective structure through the fabrication of mesoporous metal oxide (SiO_2) thin film coatings on Pd nanodisks produced via Hole Mask Colloidal Litography (HCL), as shown in Figure 1a-b, instead of low resistance polymeric membranes. Mesoporous metal oxide structures are produced using the sol-gel method, and the coatings are applied to using the spin coating technique. The mesopores present in the metal oxide thin film coating depend on various parameters such as precursor source, surfactant type and acid-base balance[4]. Additionally, the RPM, coating time, solution quantitiy during spin coating, as well as calcination temperature and time are parameters that affect the porous structure. By optimizing all these parameters, our goal is to create a selective layer on Pd nanodisks and get optical readouts even on H_2+CO environment, Figure 1c, which only allows the entry of hydrogen molecules.

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