Palladium Based Hydrogen NanoSensors

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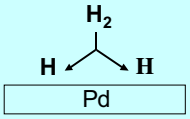
Motivation

Hydrogen sensors are essential elements for the implementation of a hydrogen economy. Current commercial sensors are too slow and too big for many applications such as on-board vehicle fuel cells. Emerging nanosensor research is currently in its early stage but shows promises in the areas of rapid detection and sensitivity. We propose to investigate new types of miniature-size hydrogen sensors with high selectivity, sensitivity and fast response times. These sensors will be based on palladium/semiconductor nanohybrids and palladium nanotubes.

Why palladium

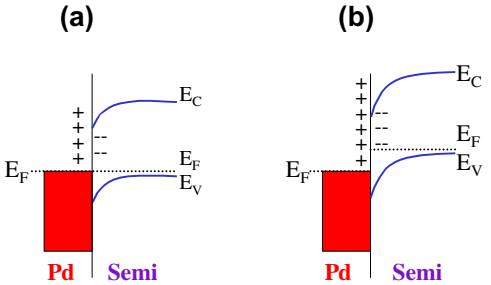


Pd as catalyst

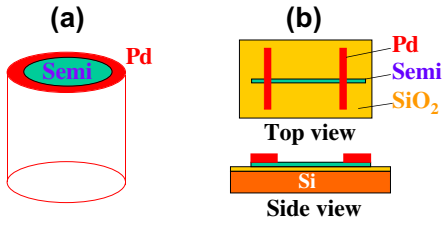
$H_2 \Rightarrow 2H$

Pd: Catalyst
High selectivity
High solubility

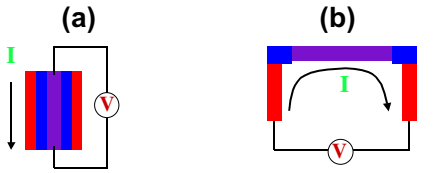
Nanohybrid Sensors



Operating Mechanism: Schottky barriers between metal and semiconductor changes in the presence of hydrogen



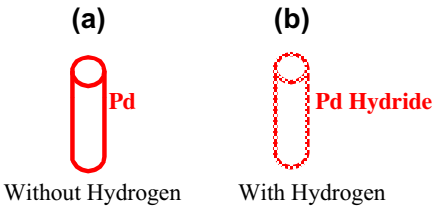
Design: Schematic of the sensors
(a) Wire/tube type; (b) transistor type



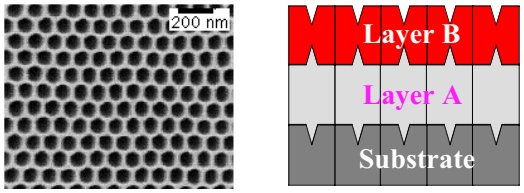
Equivalent Circuits of the sensors
(a) Wire/tube type and (b) transistor type
Schottky resistance; Resistance of the palladium
Resistance of the semiconductor (Semi)

Short diffusion distance: High speed
Exponential change of resistance: High Sensitivity
Extra Control by biasing silicon substrate

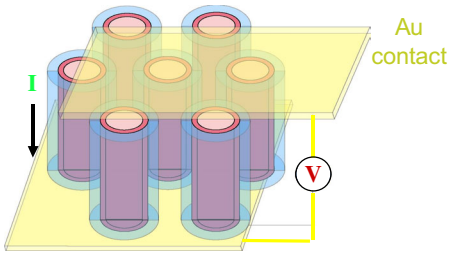
Nanotube Sensors



Operating Mechanism: Resistance changes due to the formation of palladium hydride in the presence of hydrogen



Nanotube Fabrication: Atomic layer deposition (ALD) method will be used to deposit palladium on the walls of nanopores in anodic aluminum oxide (AAO) membrane (a) Nanopore arrays in AAO membrane, (b) Schematic illustration for atomic layer deposition (ALD) process.



Equivalent Circuits of the sensors

Short diffusion distance: High speed
Large number of nanotubes: High signal/noise ratio

BES - DOE

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