Highly Stable and Reliable Lightweight Hydrogen Sensors for Fuel Cells

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Start Date = January 1, 2005
Planned Completion = March 31, 2007

Research Goals and Objectives

- To use a multidisciplinary approach and nanotechnology methods to develop ZnO nanorod sensors .The goal is to have ppm sensitivity for selective detection of hydrogen at room temperature and to integrate combine these sensors with self-powering wireless communication circuits. The overall power consumption should be minimized .The team includes materials, chemical engineering and electrical engineering expertise.
- Applications of such systems would include:
  detection of fuel leaks in space-craft or hydrogen distribution systems, with wireless data transmission to a central monitoring site.
- Our objective is to exploit nanotechnology to achieve superior detection sensitivity and low power consumption

Relevance to Current State-of-the-Art

- Current detectors are generally based on thin films. Nanowires are expected to have lower power consumption and higher detection sensitivity based on their small size but large surface-to-volume ratio.
  Novel nano-sensor devices to improve sensitivity, reliability, and robustness, while reducing power consumption.
  High efficiency and low power wireless communication circuit.
  Self-powered by energy harvesting devices for energy efficient, long lifetime operation

Relevance to NASA

- Safety issues in the detection of fuel leaks in space craft and during the production, storage and transport of hydrogen (Hydrogen concentration in air reaches a dangerous level at 4%. ppm-level detection is needed)

Budget, Schedule and Deliverables

- Budget $35K in FY04
- Collaboration of 4-men team (Pearton-processing, Ren-processing, Norton-materials, Lin-wireless circuits and integration)
- Deliverables: A prototype of integrated nanorod sensor, detailed schematics, simulation of the sensor performance, and test result.

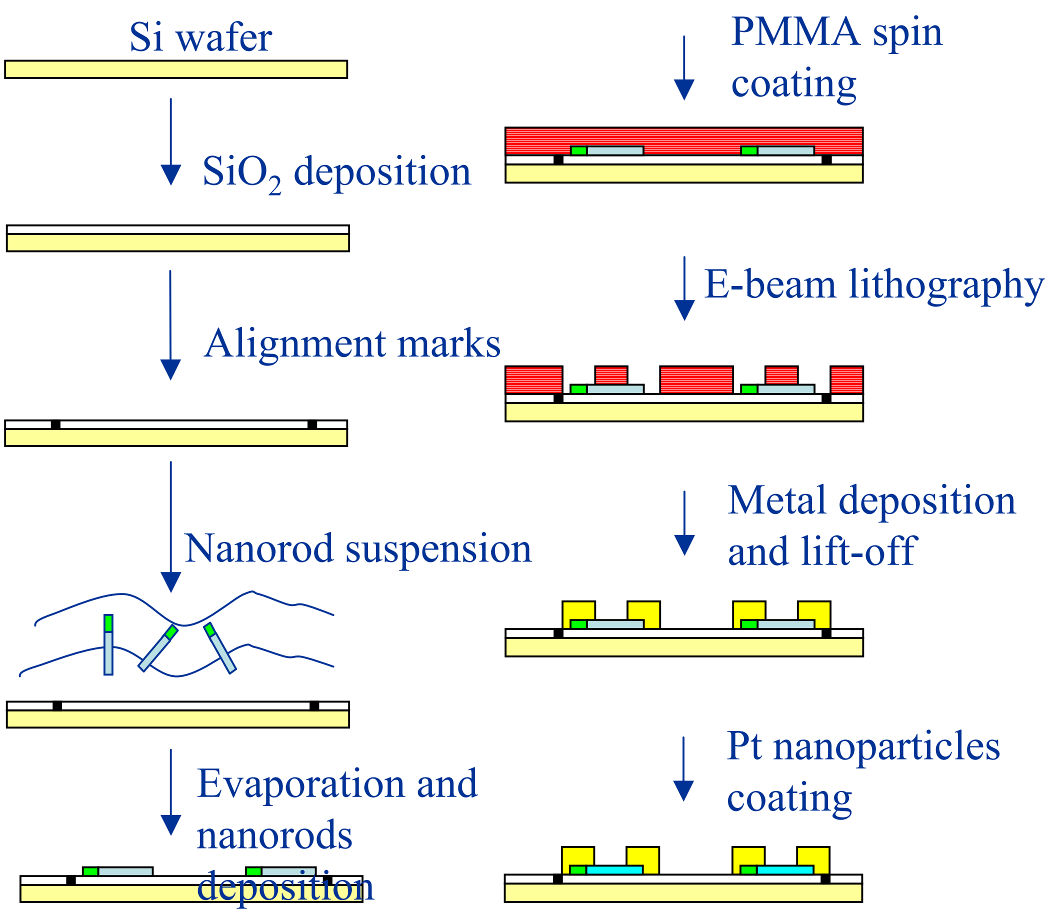
Anticipated Technology End Use

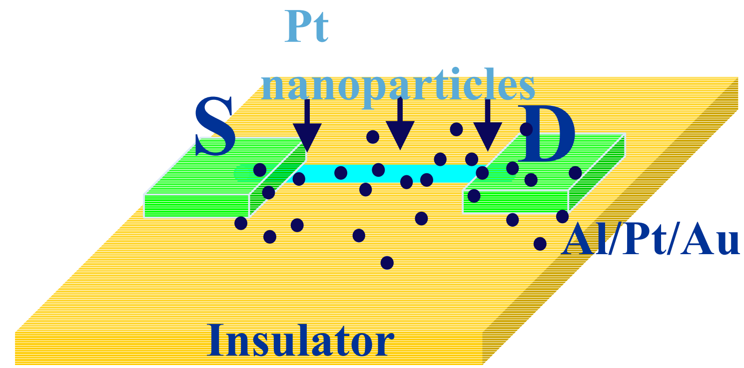
- Distributed wireless sensor network with low power consumption, small size, lightweight, low cost, long lifetime, low maintenance effort
- Low power, small size, lightweight, low cost → Nano-sensors and Nano-electronics
- Long lifetime, low maintenance → Self-powering.
- → Self-powered wireless hydrogen sensor

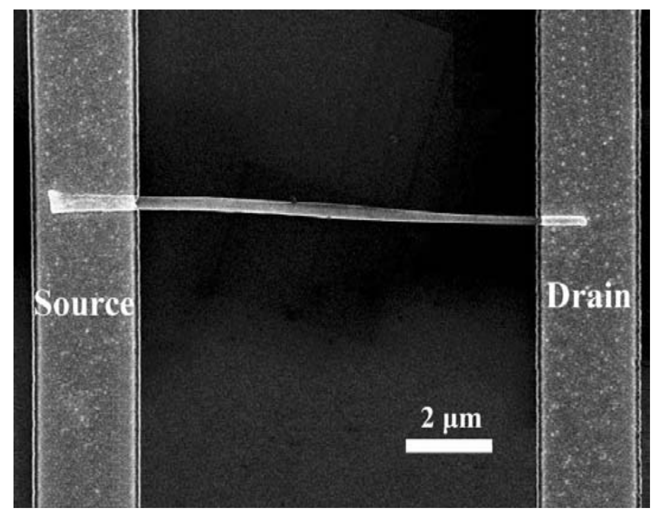
Accomplishments and Results

- Fabricated single nanorod ZnO nanowire sensors and compared results to those from both thin films and multiple ZnO nanorod sensors
- The fabrication of the single nanorod sensors is more complicated, but the resultant power consumption is much less,0.03mW for single nanorods versus 0.4mW for multiple nanorods
- Both types are selective for hydrogen detection in air at room temperature

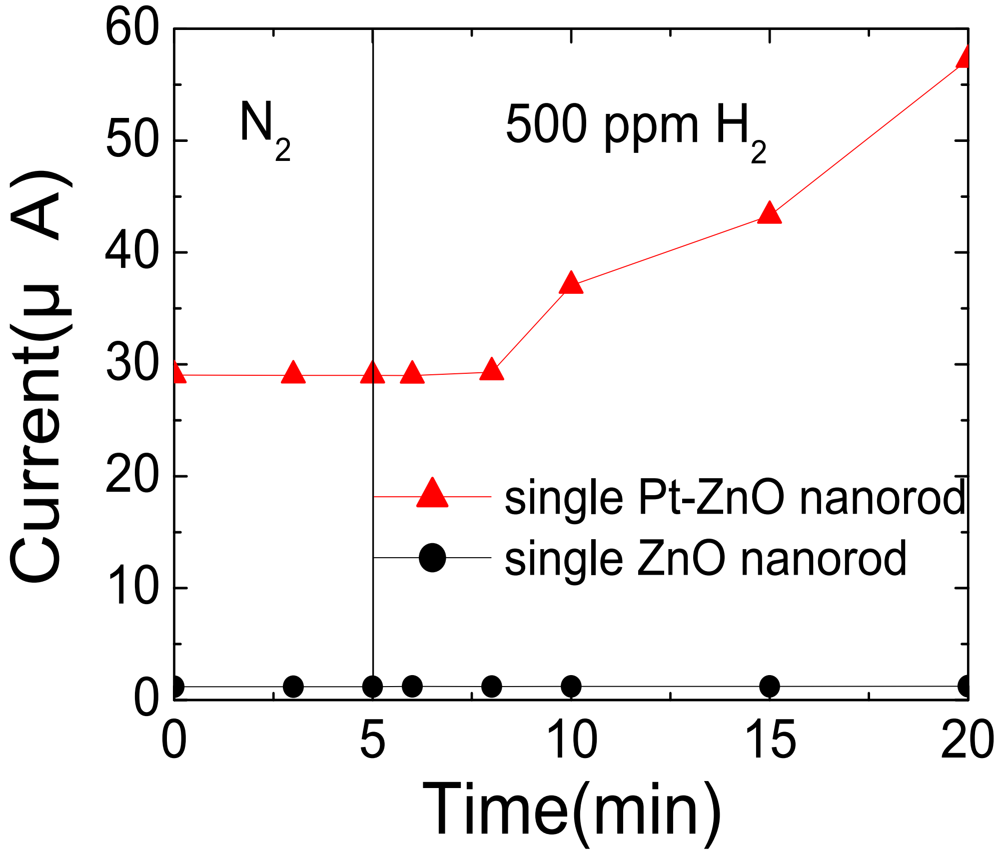
Device Fabrication-Single Nanorod





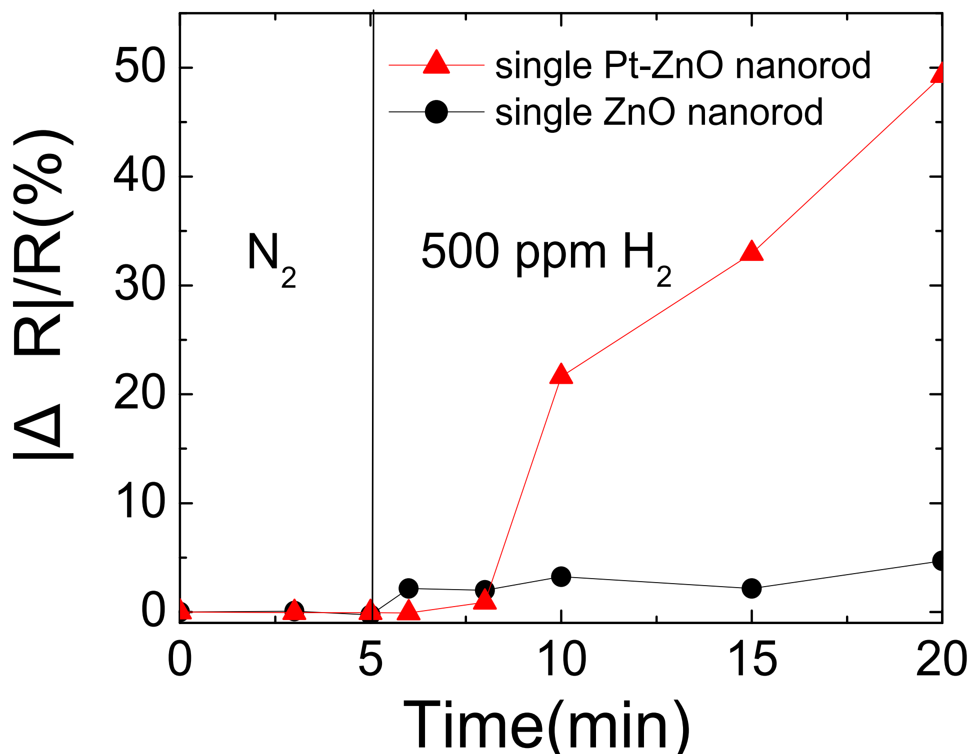


Pt-ZnO Single Nanorod Sensor



500ppm H_2 test by with and without Pt-coated single nanorod (V=0.5V).

Pt-ZnO Single Nanorod Sensor



500ppm H_2 test by with and without Pt-coated single nanorod (V=0.5V).

Comparison of Single and Multiple Nanorods

	Multiple Nanorods	Single Nanorod
fabrication	easy	complicated
ΔI	72μA	29μA
$\Delta R/R_0(\%)$	8.20%	49%
Power	0.4mW	0.03mW

Future Plans

- Testing of the nanowire sensors at temperatures below room temperature, as suggested by NASA monitors previously, to simulate the environment in some terrestrial applications.
- Work with rest of team to address integration issues of the nanorod sensors with micro-temperature control circuit, bias control circuit, current-voltage detection circuit, and signal transmission circuit. Fabrication of the integrated sensor.
- Simulation and testing of the prototype.