**Nanowire Gas Sensors (FZ2-11)**

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**Introduction**

Nanotechnology is currently one of the hottest scientific research topics around the world, because of its wide applications in fields such as medicine, energy, heavy industry, and consumer goods. Our project investigated the usefulness of using zinc oxide (ZnO) nanowires for the sensing of nitrogen dioxide (NO₂), lighter fuel gas (C₄H₁₀), and water vapor (H₂O). We also designed a portable water vapor gas sensor. We chose to look at ZnO nanowires because of its large surface-to-volume ratio which is ideal for gas sensing, and we chose to sense NO₂ and C₄H₁₀ because they are dangerous gases that should be monitored for safety.

**Methodology and Fabrication Results**

**Fabrication of Nanowires (Electrospinning)**

First a precursor solution is prepared using 1.5g of zinc acetate dihydrate, 2g of polyvinyl alcohol, and 20g of DI water. After the solution is stirred uniformly on a hotplate, it is poured into a syringe, with the needle of the syringe suspended 70cm above a piece of grounded aluminum foil. A voltage of 7kV is added to the metal needle of the syringe, causing the solution to be ejected in a stream from the needle at high speed. After the precursor threads are collected on a silicon oxide chip, they are annealed at 450°C for 1-2 hours to form zinc oxide nanowires.

**Fabrication of Nanowires (Chemical Vapor Deposition)**

First clean silicon water chips are coated with catalytic gold nanoparticles using a gold colloid solution. Next the chips are placed in a test tube with zinc powder and heated to 700°C in an atmosphere with oxygen. The gold nanoparticles liquify, and the zinc powder vaporizes and collects in the gold liquid drops; once the drops reach a critical size, zinc oxide nanostructures will precipitate.

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**Sensing Results and Discussion**

**Water Vapor**

This is the response curve, current (ampere) versus time (seconds), over 2.5 minutes of testing, of our nanowires to different concentrations of water vapor. At higher concentrations the response slope is steeper, indicating higher sensitivity at those concentrations. However at low concentrations the response time is longer, around 1 minute.

**Nitrogen Dioxide**

These are the response curves, current (nanoampere) versus time (seconds), over 14 minutes of testing, of our nanowires to different concentrations of nitrogen dioxide. At higher concentrations the response slope is steeper, indicating higher sensitivity at those concentrations. However at low concentrations the response time is longer, around 1 minute.

**Lighter Fuel Gas (Butane)**

This is the response curve, current (ampere) versus time (seconds), over 1 minute of testing, of our nanowires to lighter fuel gas, as delivered by a cigarette lighter. The response is quick and relatively sustained while the gas is applied; however the self-refresh ability of the nanowires to lighter fuel gas is not good, as shown by the decreased response the second time the gas is applied.

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**Portable Water Vapor Sensor: Circuit Design**

This is the final configuration of the sensor circuit. The 7805 provides a stable 5V for the rest of the circuit, and the nanowires are modeled as a variable resistor. The operational amplifier and feedback network is shown by the triangle, and the transistor on the right drives the LED to light up when the nanowires sense water vapor. So when the user blows on the nanowire chip shown in the right picture, the red LED on top will light up.

**Conclusion**

The performance of the electrospin fabricated zinc oxide nanowires as gas sensors was tested, and found to be satisfactory for nitrogen dioxide and water vapor; however further investigation can be carried out to increase the nanowire sensitivity and reliability to lighter fuel gas.

The portable water vapor sensor had fast reaction times to the water vapor in human breath. Possible further improvements on the circuit could be digitally converting the nanowire output signal, and using it to drive output of an array of LEDs for more accurate humidity sensing.

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