A Study and Evaluation of Meat Freshness using Tin Oxide Nanomaterial e-Nose Sensor

Abstract

The study examined the effect of applied magnetic field (AMF) on the surface morphology and elemental composition of tin oxide (SnO2) nanomaterials using Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray (EDX) Analysis. Photoluminescence characterization was also completed using Applied Spectral Imaging SD-300. The current – voltage (IV) characteristics were determined using the Keithley 2400 Source Meter and Keithley 2010 multimeter, the result from which the resistivity of the sample was computed. The study also explored the gas sensing capability of the synthesized nanomaterials.

The nanomaterials were produced using the HVPG deposition method where fused quartz tubes containing 35 mg of SnO2 powder were evacuated down to 10-6 Torr and annealed at a temperature of 1,200 ºC at growth time of 4 hours, 6 hours, and 8 hours with a ramp time of 40 minutes using a Thermolyne horizontal tube furnace. The magnetic field intensity was varied to 2500 gauss and 3100 gauss as well as the position of the permanent magnet along the tube.

In the absence of AMF, the diameters of the grown structures was found to be directly proportional to the growth time. With the presence of AMF, nanowire formation was favored with a more defined structure and greater density when the magnet is farther from the furnace, section 3b, and at greater intensity, 3100 gauss. A greater density of nanowire deposit at the mentioned section was also observed in longer growth time, 8 hours. On the other hand, lower magnetic field intensity, 2500 gauss, was observed to produce lower density and length of structures. The presence of the external magnetic field, along with the presence of temperature gradient, was found to be responsible for the formation of the homogenized nanowires. However, the temperature gradient has a greater influence than the presence of external magnetic field in the growth of the nanowire. EDX confirms the presence of tin oxide on the structures formed in sections of the tube.

Most of the samples in the absence of AMF showed blue light emission giving an energy gap around 2.6 eV – 2.9 eV. While, the experimental samples applied with external magnetic field showed red light emission as well, with greater area of luminescence in the 3100 gauss AMF set-ups, giving an energy gap around 1.7 eV– 1.9 eV with lower energy gap for longer growth time, 8 hours.

In the absence of AMF, the values of the resistance and resistivity were found to increase with increasing growth time. Meanwhile a decrease in the resistivity of the sample was observed as the AMF intensity and the growth time increased. The nanostructures synthesized with AMF under the optimized condition were found to be sensitive to CO2 gas, acetone, and methanol vapor. It was also able to detect spoiled meat headspace gas

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About the Author

Dr. Gil Nonato C. Santos is a Full Professor and Chairman of the De La Salle University Physics Department. He has an undergraduate and graduate degree in Physics at De La Salle University and University of the Philippines and a Doctorate degree in Materials Science and Engineering at the University of the Philippines Diliman National Institute of Physics. He is a Research Fellow at the University of Fukui doing research of nanocomposite materials and its terahertz applications, and Visiting Professor in Osaka University Quantum Engineering Laboratory and at Howard University's Atmospheric Science Research Laboratory . He is the Research Head of the Solid State Physics Laboratory, Inanolab research facility, and had published local and international publications in Nanomaterials. He has a patent work for growing nanomaterials called the horizontal vapor phase growth (HVPG) technique. He is the convenor of Philippine Association of Physics and Science Instructors and was awarded Most Outstanding Service Award in 2010 by the Philippine Physics Society. In 2012, he was a recipient of the Challenge Grant for establishing an Air Weather Observation System for De La Salle Philippines and Volunteer Schools called SIGWA (Students Involve in Geophysical Weather and Atmospheric studies) and an AKI grant for developing a nanosensor for detecting meat spoilage. He also obtained a research grant from DOST for developing Tin Oxide Silver Nanocomposite materials for antiheat and antibacterial applications and a US Aid Carwin Grant for developing nanocomposite materials for anticorrosion and antibarnacle applications for ship hull.