SESSION A7: Integration
Chairs: Elisabetta Di Bartolomeo and Dong-Ming Lin
Wednesday, Afternoon, December 1, 2004
Back Bay D (Sheraton)

1:30 PM A7.1
Micro Gas Sensors Operating at Room Temperature, Duk-Dong Lee and Kap-Duk Song; School of Electronic & Electrical Engineering, Kyungpook National University, Daegu, South Korea.

It is well known that most of the semiconductor type gas sensing devices can be operated at the elevated temperature. So the considerable power consumption for the operation of gas sensing device is known to be avoidable. But, until now, the attempts to minimize the power consumption have been made by many researchers. The results of the study on low power gas sensor can be summarized by two categories; one is to miniaturize the device size and the other is to apply some appropriate materials. In the study, low power gas sensors operated at room temperature for the detection of NH3 and NOx gases are proposed. As candidate material of gas sensor for NH3 gas detection at room temperature, polyaniline(PANI) synthesized by chemical polaronization was selected. And Te(Tellurium) thin film was used for NOx gas detection at room temperature. By using these sensing materials, micro gas sensors for room temperature operation were prepared and measured the response characteristics for NH3 and NOx. In case of PANI sensor, the structure was proposed to be used having advantages of being useful one for Lab-On-a-Chip. The operating principle of the sensor is based on the change in work function of PANI film caused by adsorption of gas molecules in air on the film surface. The change in work function was measured indirectly from that in gate voltage of the FET device. The response to various gases (NH3, CH4, CO and NOx) was obtained in gate voltage step mode in R.H. 30%. And in case of Te sensor, the sensing material was thermally evaporated on glass substrate. The thickness and annealing temperature were 500 Å—3000 Å and 100°C—300°C, respectively. And Ti was added to Te film. So the resistance at room temperature is much lower than that of metal oxide semiconductor. The Te-based micro gas sensor exhibited high sensitivity to NOx and good selectivity against CO and hydro-carbon gases.

2:00 PM A7.2
SiGe Thermoelectric Film for Gas Sensor Micro-Devices, Wossack Shin, Kazuki Tajima, Yeongsoo Choi, Noriyu Izu, Ichiro Matsubara and Norimitsu Murayama; Advanced Manufacturing Research Institute, National Institute of Advanced Industrial Science and Technology, Nagoya, Japan.

A gas sensor micro-device using both thermoelectric film and catalyst film has been developed on the platform where the operating temperature of the sensor is continuously changed to achieve desired response characteristics, known as a micro-hotplate. SiGe thin films were deposited on the SiN/SiO2/Si substrate by RF-sputtering and thermal annealing was carried out to crystallize the as-deposited, amorphous-like SiGe thin films. With increasing the annealing temperature and time, the crystallization of the SiGe thin film progressed, resulting in higher carrier mobility and large absolute value of Seebeck constant. The micro-heater and the electrodes were patterned by photolithography and lift-off technique. After the back-side etching of Si substrate, the catalyst layer was deposited on the membrane structure. The hydrogen sensitivity of the micro-thermoelectric gas sensor was investigated for various gas concentrations and device working temperatures.

2:15 PM A7.3
Integration of Microcatalysts on Thin Membrane for Thermoelectric Gas Sensor Devices, Yeongsoo Choi, Wossack Shin, Kazuki Tajima, Noriyu Izu, Ichiro Matsubara and Norimitsu Murayama; Sensor Integration Group, Advanced Manufacturing Res.Inst. AIST, Nagoya, Japan.

In order to fabricate a highly efficient thermoelectric hydrogen sensor (THS), a dispensable film application of a few layers of pentacene OTFTs can be used to make sensitive humidity sensors. In the current work, we demonstrate the applicability of OTFTs for detecting biological species in aqueous environments. Pentacene OTFTs were fabricated on Si substrates by vacuum-deposition. We will also discuss unusual OTFTs based on the doped conducting polymer poly(ethyleneoxy-thiophene)-polystyrenesulfonate (PEDOT:PSS) and the application of these transistors to DNA and glucose sensing.

2:30 PM A7.4
The Development and Evaluation of TiO2 Nanoparticle Films for Conductomeric Gas Sensing on MEMS Microhotplate Platforms, Kurt D. Benkoetem and Steve Semancik; CSTL, National Institute of Standards and Technology, Gaithersburg, Maryland.

Over the past decade, MEMS microhotplate devices have been developed at the National Institute of Standards and Technology to support semiconductor metal oxide films for use in conductometric gas sensor arrays. In most cases, the materials have been based on compact thin films of SnO2 or TiO2 as deposited by single-source precursors. In recent years, we have begun to study other materials. Of particular interest to our group is the enhancement of the sensitivity of the sensors to trace gas species by inducing nanostructured porosity and large internal surface areas in the films. In this presentation, we discuss the development of nanostructured sensor materials based on porous TiO2 nanoparticle thin films. The preparation and evaluation of pure and niobium-doped TiO2 nanoparticle films are described. The films on the MEMS microhotplate substrates are evaluated as conductometric gas sensors based on the critical performance elements of sensitivity, stability, speed and selectivity. Rapid control of the sensor operating temperature, an inherent benefit of the microhotplate platform, is employed to improve the performance of the nanoparticle films as sensor materials. The sensor performance for the novel nanoparticle TiO2 films is compared with that of traditional compact CVD-derived films.

2:45 PM A7.5
Low-Cost Integrated Sensors Utilizing Patterned Nano-Structured Titania Arrays Fabricated Using a Simple Process, Zaruzi Abu Saleh1, Andrei Kolmakov1, Martin Moskovits1 and Noel C. MacDonald2; 1 Materials Department, University of California, Santa Barbara, California; 2Chemistry and Biochemistry, Department, University of California, Santa Barbara, California; 3Chemical and Environmental Engineering Department, University of California, Santa Barbara, California.

Chemical sensors are used in a variety of areas such as process control, healthcare, automotive, aerospace and environmental monitoring. Because of their importance, a few critical issues are associated with the design and production of high performance chemical sensing devices must be addressed. These include requirements for low cost, miniaturization, and compatibility with large volume manufacturing processes. These issues could be mitigated by developing processes that take advantage of the inherent 'batch-processing' property of microfabrication techniques. In addition, use of microfabrication techniques allows integration of sensing elements with advanced electronics on a single chip. Nanostructured titania (n-titania) has been used for sensing a variety of gases as well as biological species. However, significant challenges of crack formation, cost issues and incompatibility of current synthesis methods with microelectronics fabrication techniques to implement crack-free n-titania (nanotube) layers by reacting Ti surfaces with aqueous H2SO4 solution. The formation of single phase nanostuctured nanotube layers on devices have been investigated using TEM, high resolution SEM, AFM, X-ray diffraction (XRD) and X-ray photoelectron spectroscopy (XPS). We have also realized sensor devices on Si chips utilizing patterned TiO2 nanostructured titania arrays as sensing elements. These sensor devices are ultra-sensitive to oxygen and can also sense hydrogen. We shall also present results of investigations to implement n-titania sensor arrays on flexible, lightweight and robust substrates. These results have implications in development of wearable and low-cost sensors.

3:30 PM A7.6
Integrated and Multiplexed Functional Nanostructures for Bio-Chem Sensors, Vinayak P. Dravid; 1 Materials Science &