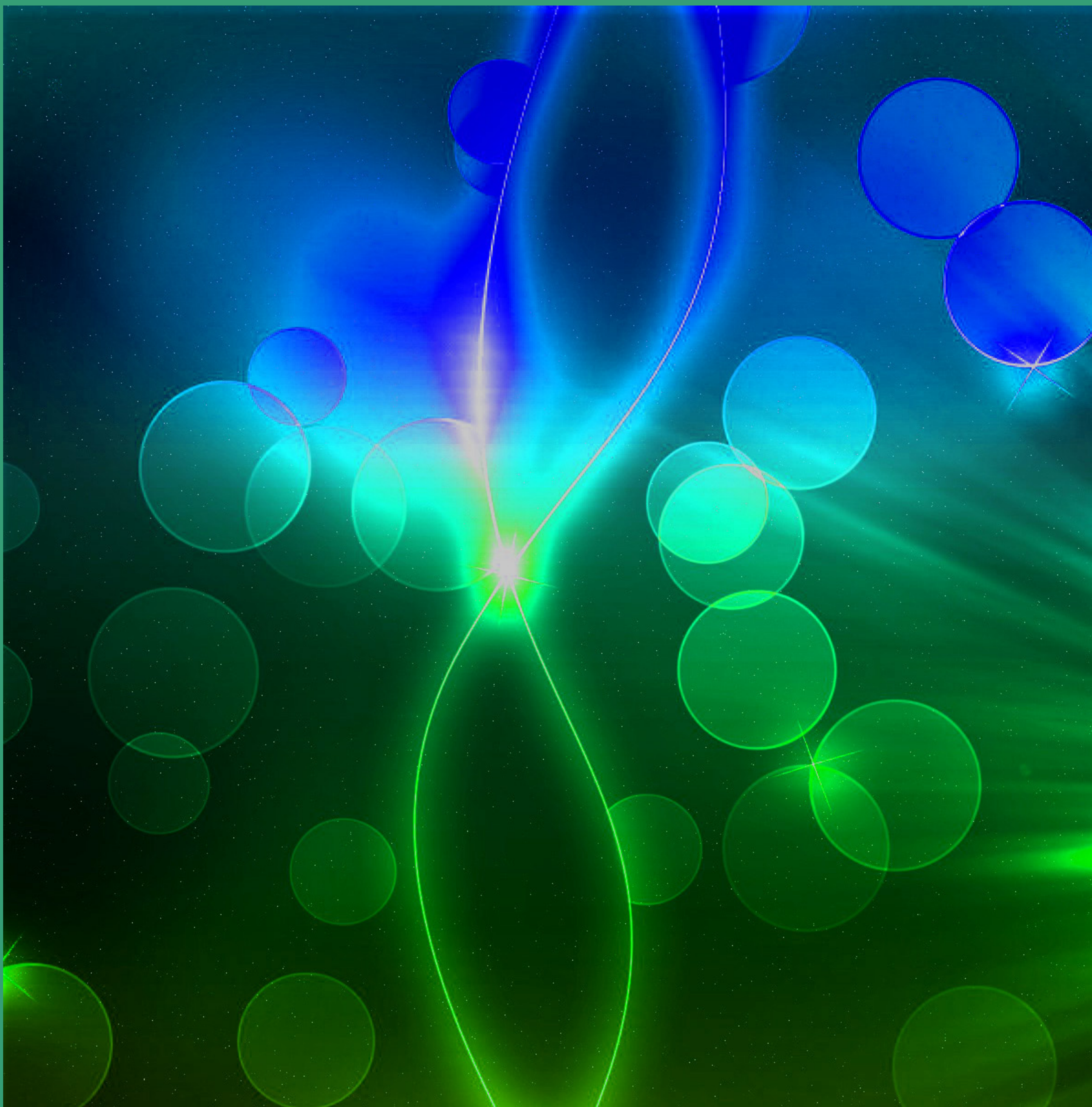
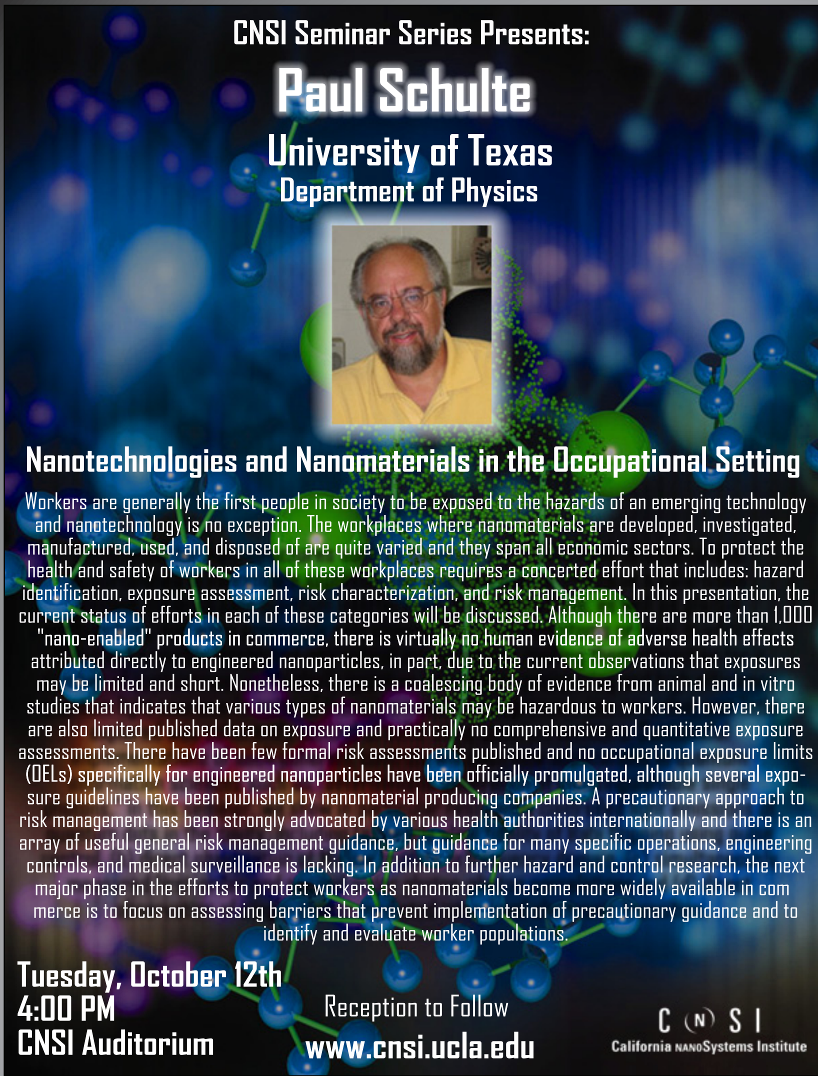
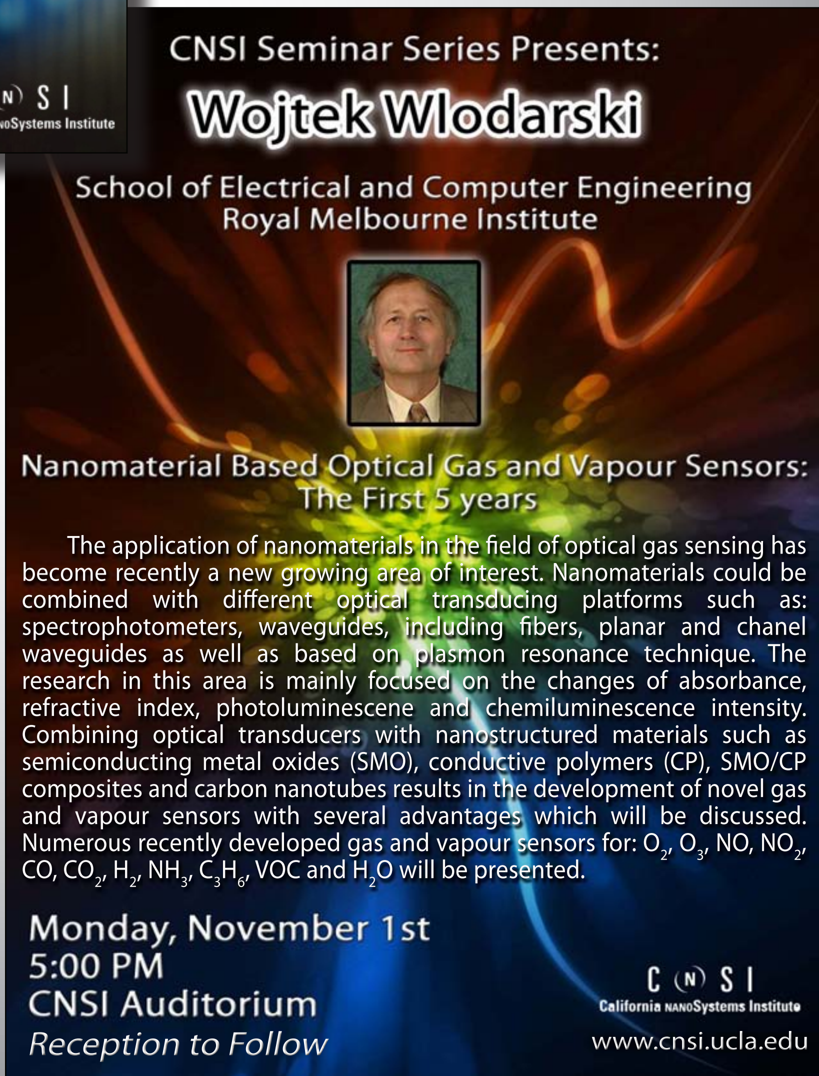
Fall 2010

Spheres

CNSI
California NanoSystems Institute




CNSI Seminar Series Presents:
Paul Schulte
University of Texas
Department of Physics
Nanotechnologies and Nanomaterials in the Occupational Setting
Workers are generally the first people in society to be exposed to the hazards of an emerging technology and nanotechnology is no exception. The workplaces where nanomaterials are developed, investigated, manufactured, used, and disposed of are quite varied and they span all economic sectors. To protect the health and safety of workers in all of these workplaces requires a concerted effort that includes: hazard identification, exposure assessment, risk characterization, and risk management. In this presentation, the current status of efforts in each of these categories will be discussed. Although there are more than 1,000 "nano-enabled" products in commerce, there is virtually no human evidence of adverse health effects attributed directly to engineered nanoparticles, in part, due to the current observations that exposures may be limited and short. Nonetheless, there is a coalescing body of evidence from animal and in vitro studies that indicates that various types of nanomaterials may be hazardous to workers. However, there are also limited published data on exposure and practically no comprehensive and quantitative exposure assessments. There have been few formal risk assessments published and no occupational exposure limits (OELs) specifically for engineered nanoparticles have been officially promulgated, although several expo-sure guidelines have been published by nanomaterial producing companies. A precautionary approach to risk management has been strongly advocated by various health authorities internationally and there is an array of useful general risk management guidance, but guidance for many specific operations, engineering controls, and medical surveillance is lacking. In addition to further hazard and control research, the next major phase in the efforts to protect workers as nanomaterials become more widely available in com merce is to focus on assessing barriers that prevent implementation of precautionary guidance and to identify and evaluate worker populations.
Tuesday, October 12th
4:00 PM
CNSI Auditorium
Reception to Follow
www.cnsi.ucla.edu
CNSI
California NanoSystems Institute


CNSI Seminar Series Presents:
Wojtek Wlodarski
School of Electrical and Computer Engineering
Royal Melbourne Institute
Nanomaterial Based Optical Gas and Vapour Sensors:
The First 5 years
The application of nanomaterials in the field of optical gas sensing has become recently a new growing area of interest. Nanomaterials could be combined with different optical transducing platforms such as: spectrophotometers, waveguides, including fibers, planar and chanel waveguides as well as based on plasmon resonance technique. The research in this area is mainly focused on the changes of absorbance, refractive index, photoluminescene and chemiluminescence intensity. Combining optical transducers with nanostructured materials such as semiconducting metal oxides (SMO), conductive polymers (CP), SMO/CP composites and carbon nanotubes results in the development of novel gas and vapour sensors with several advantages which will be discussed. Numerous recently developed gas and vapour sensors for: O_2, O_3, NO, NO_2, CO, CO_2, H_2, NH_3, C_3H_6, VOC and H_2O will be presented.
Monday, November 1st
5:00 PM
CNSI Auditorium
Reception to Follow
CNSI
California NanoSystems Institute
www.cnsi.ucla.edu

Fall 2010

contents

Published by the California NanoSystems Institute at UCLA

Editors
Andrea Delgado
Jennifer Marcus

Graphic Design & Layout
Andrea Delgado

Seminar Series Posters
Michael Dickerson

Photography
Andrea Delgado

Acknowledgments
Nikki Lin
Jennifer Marcus
Paul Weiss

Contact Address

CNSI
570 Westwood Plaza
Building 114, MC 722710
Los Angeles, CA 90095-7227
USA

Subscription

Please send requests for a quarterly subscription along with your name, title, contact details and affiliations to cnsiadmin@cnsi.ucla.edu schulte

Nanotechnologies and Nanomaterials in the Occupational Setting

Paul Schulte

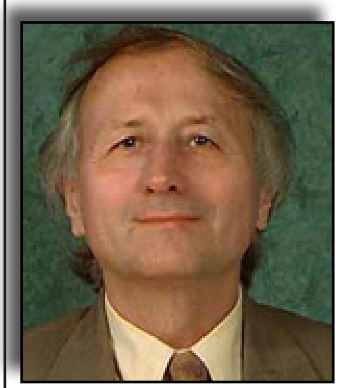
The National Institute for Occupational Safety & Health (NIOSH)

Workers are generally the first people in society to be exposed to the hazards of an emerging technology. Nanotechnology is no exception. The workplaces where nanomaterials are developed, investigated, manufactured, and handled vary largely and span all economic sectors. Protecting the health and safety of employees in all of these workplaces requires a concerted effort, including hazard identification, exposure assessment, risk characterization, and risk management. In his presentation, Paul Schulte, from the National Institute for Occupational Safety and Health, discussed the current status of efforts in each of these categories. Although there are more than one thousand "nano-enabled" products available commercially, there is virtually no human evidence of adverse health effects attributed directly to engineered nanoparticles. This situation is, in part, due to current observations that exposures may be limited and short. Nonetheless, there is a coalescing body of evidence from animal and *in vitro* studies indicating that various types of nanomaterials may be hazardous to workers. There are, however, limited published data regarding exposure, and practically no comprehensive and quantitative exposure assessments. Only a few formal risk assessments have been published. Occupational exposure limits (OELs) that are specific to engineered nanoparticles have not been officially promulgated, although several exposure guidelines have been published by nanomaterial-producing companies. A precautionary approach to risk management has been strongly advocated by various international health authorities and there is an array of useful general risk management guidance. Guidance for many specific operations, engineering controls, and medical surveillance is, however, lacking. As nanomaterials become more widely available commercially, the next major phase in the effort to protect workers, in addition to further and control research, will focus on assessing the barriers preventing the implementation of precautionary guidance and identifying and evaluating worker populations. ♦

wlodarski

Nanomaterial-Based Optical Gas and Vapor Sensors: The First Five Years

By Maher El-Kady



Wojtek Wlodarski

Royal Melbourne Institute of Technology

Professor Wlodarski began his presentation emphasizing the development of sensors, which have become increasingly important in recent years, flourishing because of the growing need for physical, chemical, and biological recognition systems and transducing platforms. Focusing on gas sensors, Professor Wlodarski discussed the characteristics of a good sensor: it should be inexpensive, reliable, and durable, while providing accurate and stable sensing, at low dilution. To meet the increasing demands of industry, new approaches to sensor technology are being explored, with nanotechnology currently exhibiting great potential. Nanotechnology enables the development of small, inexpensive, and highly efficient sensors for broad applications. Professor Wlodarski provided an overview of the different classes of nanostructured materials that have been used in the last five years, including conducting polymers, metal oxide semiconductors, and carbon-based nanostructures, such as carbon nanotubes and graphene. Nanocomposites prepared from these components produce new nanostructured materials, the properties of which can be tailored for specific sensing applications.

Among the different sensors used to detect gases, optical sensors are the most interesting because of their simplicity, light weight, small size, and high sensitivity. As a result, several optical transducing platforms based on plasmon resonance techniques, such as spectrophotometers and waveguides, have been commercialized. In optical sensors, detection is based on changes in the optical characteristics of the medium as a result of the interaction of the sensing element with the target gas. These changes can occur to the optical absorption, refractive index, photoluminescence, chemiluminescence, and surface plasmon resonance. Professor Wlodarski presented a thorough overview of the ways these sensing platforms work in optical sensors, as well as the physical effects involved in signal transduction. He noted that the development of novel gas sensors is achieved by combining optical transducers with nanostructured materials.

Professor Wlodarski provided many examples from existing papers describing the sensing of various gases and volatile organic compounds. Notably, nanomaterials have been implemented in optical sensor arrays for the identification of various gases without interference. An exciting example came from a Chinese group who published their results last year (Anal. Chem. 2009, 81, 961-966). They designed nanomaterials-based sensor arrays that could tell the difference between 11 flavors commonly used in cigarettes, with each flavor triggering its corresponding unique optical pattern. Another example that attracted the audience's attention came from Georgia Tech engineers who examined the size-induced quantum confinement in ZnO nanobelts through photoluminescence measurements (Mater. Today 2004, 7, 26-33). It is clear that nanomaterials enhance the interactions that occur at the nanoscale, imparting these optical sensors with significant advantages over conventional sensors. ♦

jonker

Silicon Spintronics

By Yi Zhou

Berry Jonker

Materials Science & Technology Division, Naval Research Laboratory

The scaling of silicon complementary metal-oxide-semiconductor (CMOS) transistors has been the main driving force of the microelectronics industry for over three decades. Today, however, it faces fundamental limits inherent in terms of physical laws and material properties. Therefore, innovative device structures and functionalities must be explored to continue the historic progress in information processing technology. Spintronics, a new paradigm of electronics based on the electron's spin degree of freedom, has the potential advantages of nonvolatility, increased data processing speed, decreased power consumption, and increased integration densities relative to conventional semiconductor devices. In his presentation, Berry Jonker addressed the importance and potential of achieving spintronics devices based on silicon, the most dominant material in the semiconductor industry.

Berry Jonker, from the Materials Science and Technology Division at the Naval Research Laboratory, began his talk by introducing his early work on diluted magnetic semiconductors (DMS), in which spin polarization in semiconductors is created by magnetic dopants. One of the critical issues of DMS, however, is thermal stability: it is difficult to obtain room-temperature magnetism in DMS for practical applications. Therefore, Jonker switched direction and began working on spin injection, which creates spin accumulation in silicon by transporting spin-polarized electrons from ferromagnetic metals (FM) into the silicon.

The critical challenge for spin injection is the conductivity mismatch problem, where electrons lose most of the spin polarization at the FM/silicon interface, due to the large difference in conductivity between the two materials. Inserting an ultrathin (usually 1–2 nm) oxide between the FM and silicon facilitates transport and typically solves the problem of conductivity mismatch. The types of oxides studied in his group include Al_2O_3, SiO_2, and MgO.

To detect the spin accumulation and transport in silicon, the Jonker group uses non-local spin valve measurement and Hanle measurement, respectively. For non-local spin valve measurement (Fig. 1), spin-polarized electrons are injected under contact 3 by applying a current between contacts 3 and 4. Even though there is no charge current flow between contacts 3 and 2, the spin current can still diffuse to contact 2 if the spin diffusion length is longer than the distance between contacts 3 and 2. As a result, the injected spin polarization can be probed from contact 2 as a voltage output. This method is typically employed for spin injection and transport measurement because it separates the charge current and spin current flow paths and eliminates artifacts, such as magnetoresistance. Hanle measurement is based on spin precession under a transverse magnetic field. This precession leads to randomized spin polarization, giving rise to a Hanle peak at zero magnetic field. Jonker has obtained evidence for spin injection and transport in silicon using both measurement techniques.

Looking to the future of spintronics research, Jonker concluded his talk by introducing some potential device concepts based on silicon spintronics.♦

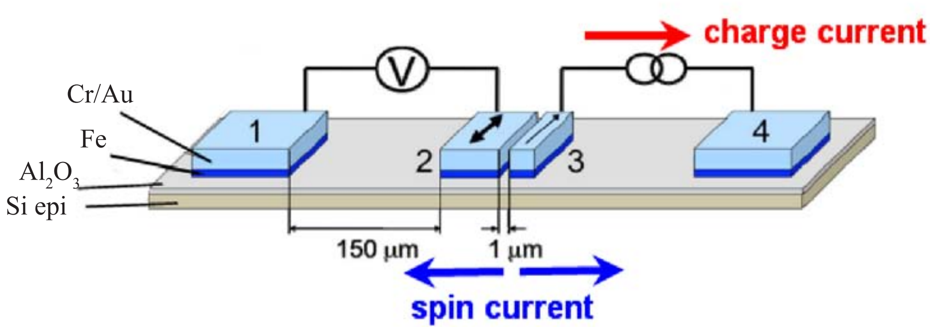


Figure 1. Non-local spin valve measurement.

tsai

Safe Handling of Nanomaterials

By Khadeeja Abdullah

Over the past two decades, nanomaterials have been the subject of enormous interest because of their extremely small size (on the order of one billionth of a meter) and potential for wide-ranging industrial, biomedical, and electronic applications. Nonetheless, uncertainty exists about the risks of nanomaterials to human health and the environment. Growing evidence suggests nanomaterials have serious toxicological endpoints. In this light, Dr. Su-Jung (Candace) Tsai, Manager of Environmental Health and Safety at the Center for High-rate Nanomanufacturing (CHN) and a researcher in the Department of Work Environment at the University of Massachusetts Lowell, has performed extensive research on exposure control methods for nanoparticles.

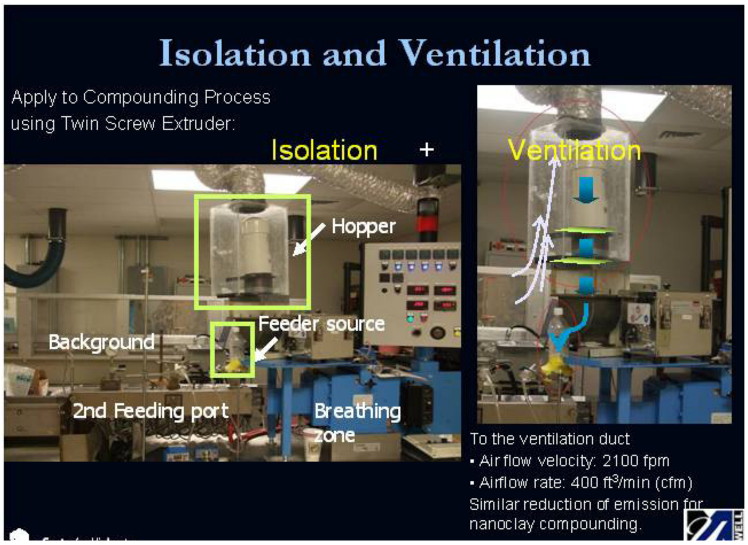


Figure 1.

The Tsai research team tested isolation and ventilation controls for a nanocomposite manufacturing system (Fig. 1). Measurements taken at the source and in the breathing zone revealed that both isolation and ventilation worked well. In another experiment, Tsai tested filter efficiencies for a system for the transporting of nanoparticles. The researchers took transmission electron microscopy (TEM) samples both upstream and downstream of the applied filter system. They tested two aerosol sampling filters (quartz and A/E fiberglass) and six environmental fabric filters (woven polyester, woven polyesters with a Teflon membrane coating, polyester felt, polyester felt with a Teflon membrane coating, polyester felt with a Goretex membrane, and filament polyester). The aerosol sampling filters had the highest efficiencies, (ca. 95%). The efficiencies of the coated fabric filters ranged from 80 to 90%; the non-coated fabric filters were the least effective, exhibiting 30–50% efficiency.

Tsai also tested conventional hood, by-pass hood, constant velocity hood, and air-curtain hood ventilation systems during manual handling procedures, such as transferring and pouring nanoparticles. The goal of the experiment was to measure the effects of the hood design, sash height, and face velocity on the degree of exposure. The researchers took background and exposure measurements in the breathing zone. Airflow in conventional hoods, by-pass hoods, and constant velocity hoods occurs in a horizontal plane, from the front of the hood to the back. When working in these hoods, the area between the arms generates a vortex that increases the nanoparticle exposure in the breaking zone (Fig. 2). Several operating conditions, such as the sash height and hood velocity, affect the degree of exposure. Conventional hoods proved to be the worst in terms of protection. A newer design not currently available in the US—air-curtain hoods—function in a different manner and proved to be the best in preventing exposure. The airflow occurs in a vertical plane from the top to the bottom, preventing vortex formation and reducing nanoparticle exposure in the breathing zone. Tsai's research illustrates the importance of appropriate control measures and how some controls are more effective than others. ♦

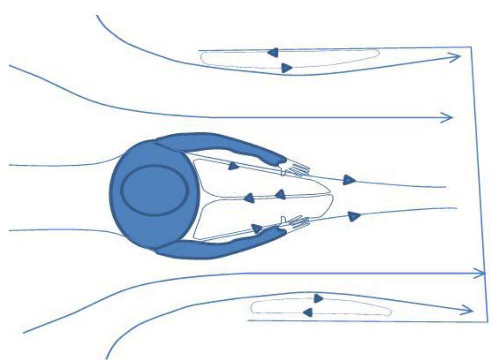
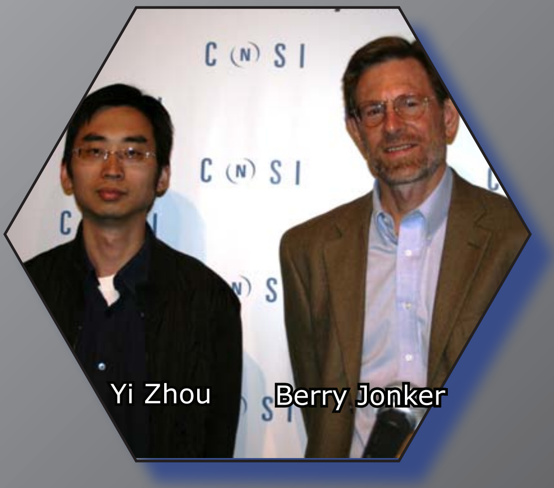


Figure 2. Airflow pattern in a conventional, by-pass, or constant velocity hood.

Su-Jung (Candace) Tsai

Center for High-rate Nanomanufacturing (CHN), University of Massachusetts Lowell

Review Authors



CNSI Seminar Series Presents:

Berry Jonker

Senior Scientist and Head of the Magnetoelectronic Materials & Devices Section in the Materials Science & Technology Division
Naval Research Laboratory

Silicon Spintronics

We describe a simple and efficient way to electrically inject spin-polarized electrons from Fe/Al2O3 and Fe/SiO2 tunnel barrier contacts into silicon, achieving a majority electron spin polarization of at least 30%. Initial measurements utilized optical detection of the circularly polarized electroluminescence resulting from radiative recombination of the spin-polarized electrons injected from a ferromagnetic metal contact [1]. Recent theoretical work provides a more quantitative interpretation of the EL polarization [2], confirming an electron spin polarization of 30%. These spin injecting contacts are utilized in a lateral transport geometry, where we generate both spin-polarized charge currents and pure spin diffusion currents using a non-local spin valve (NLSV) structure. We demonstrate that we can manipulate and electrically detect the polarization of the pure spin current [3,4] as required for information processing. This pure spin current produces a net spin polarization and an imbalance in the spin-dependent electrochemical potential, which is detected as a voltage by a second magnetic contact outside of the charge flow path. The spin polarization is determined by both the magnetization/bias of the injector contact and spin precession induced by a magnetic field applied normal to the surface (Hanle effect). The Hanle measurements yield spin lifetimes ~ 1ns at 10K for lateral transport in n-doped Si (~ 4x1018 cm-3) [3]. Similar measurements probe the spin accumulation directly under the injecting contact. We observe Hanle precession of electron spin accumulation in Si for a wide range of bias conditions, show that the magnitude of the Hanle signal is in good agreement with theory, and that the spin lifetime varies with the Si carrier density. These results confirm spin accumulation in the Si transport channel well above 300K rather than trapping in localized interface states, and enable utilization of the spin variable in practical device applications.

References: [1] B.T. Jonker et al, Nature Phys. 3, 542 (2007); C. Li et al, APL 95, 172102 (2009); G. Kioseoglou et al, APL 94, 122106 (2009).
[2] P. Li and H. Dery, arXiv:1003.1709v2, accepted Phys. Rev. Lett.
[3] O.M.J. van t'Erve et al, APL 91, 212109 (2007).
[4] O.M.J. van t'Erve et al, IEEE Trans. Elec. Devices 56 (10), 2343 (2009).

Tuesday, November 9th
4:00 PM
CNSI Auditorium
Reception to Follow

CNSI
California NanoSystems Institute
www.cnsi.ucla.edu

CNSI Seminar Series Presents:

Su-Jung (Candace) Tsai

University of Massachusetts Lowell
Manager of Environmental Health and Safety at the Center for High-rate Nanomanufacturing (CHN)

Occupational and Environmental Health and Safety for Nanotechnology: Setting the Pace for the Next Phase

With nanotechnology moving from development to commercialization at a more rapid rate, so too are calls for a more comprehensive understanding of the environmental and occupational health risks associated with various nanomanufacturing processes. There are indications that a range of engineered nanomaterials, including nanoparticles, agglomerates of nanoparticles, and particles of nanostructured materials, are likely to present potential risks to human health and the environment. Possible negative properties of these materials include their ability to penetrate dermal barriers, cross cell membranes, travel neuronal pathways, breach the gas exchange regions of the lung, travel from the lung throughout the body, and interact at the molecular level. In particular, critical reviews on the toxicity of carbon nanotubes (CNTs) give credence to research that indicates damage to lung tissue in mice.

We have the opportunity to address occupational and environmental health and safety issues in a sustainable manner from the beginning. It is extremely important that all researchers and manufacturers working with engineered nanoparticles incorporate sustainable practices into their work. This talk will review the current knowledge about occupational and environmental exposures to engineered nanoparticles and techniques for evaluating and controlling such exposures. Case studies from our research will be discussed. In addition, the current consensus on best practices for working with engineered nanoparticles and the challenges presented by the next phase will be presented and discussed.

Thursday, December 2nd
4:00 PM
CNSI Auditorium
Reception to Follow

CNSI
California NanoSystems Institute
www.cnsi.ucla.edu