Tuesday Afternoon, November 14, 2006

Nanometer-scale Science and Technology
Room 2016 - Session NS-TuA

Nanoscale Devices and Detection

Moderator: S. Wind, Columbia University

2:00pm **NS-TuA1 Magnetization Reversal by Spin Injection: Ultra-fast and Ultra-small***, Y. Acremann,* Stanford University **INVITED**

Invited Speaker Dan Ralph's talk eplaced with Yves Acremann, Stanford University.

2:40pm **NS-TuA3 Single-Crystal/Amorphous Si-SiO2 Multilayer Systems and Devices based on Si Nanomembranes***, W. Peng, M.M. Roberts, F.S. Flack, E.P. Nordberg, D.E. Savage, M.G. Lagally, M.A. Eriksson,* University of Wisconsin-Madison

Silicon-on-insulator (SOI) is widely used in device applications that require single-crystal Si but benefit from the isolation provided by a SiO2 substrate layer. Multiple layers of single-crystal Si interspersed by (amorphous) SiO2 are a natural next step for SOI devices. It is impossible to achieve such a system by growth techniques (one cannot grow single-crystal Si on SiO2), and multiple bonding steps, such as those used to create conventional SOI, would be prohibitively expensive. We demonstrate a novel method to fabricate such a multilayer Si-SiO2 system using transferred silicon nanomembranes@footnote 1@ and subsequent oxidation. The surface roughness and interface quality for the multilayer system is similar to prime SOI. We describe devices, including Bragg mirrors and resonant tunneling diodes that take advantage of the properties of repeated layers of single-crystal Si and amorphous SiO2. Extremely high reflectivity (~98%) is observed for Bragg reflectors with as few as four Si layers, as expected from the large dielectric contrast between the silicon and silicon-dioxide layers. @FootnoteText@ Supported by NSF, DOE, AFOSR.@footnote 1@ Roberts, M. M. et. al. Elastically relaxed free-standing strained-silicon nanomembranes. Nature Materials 5, 388-393 (2006).

3:00pm **NS-TuA4 Characterization of Ga-Acceptor Nanoscale Wires in Si***, S.J. Robinson, J.R. Tucker,* University of Illinois at Urbana-Champaign*; T. Schenkel,* Lawrence Berkeley National Laboratory*; T.-C. Shen,* Utah State University

The prospect of using focused ion beams (FIBs) as maskless implants has gained popularity since the inception of the FIB. In particular, nanoscale interconnects and quantum devices could be defined by implantation of dopant atoms into semiconductors. We have used a FEI dual beam Strada 235 FIB at LBNL to fabricate high-density Ga wires in Si substrates to study the transport properties and practicality of these wires. Under similar annealing conditions, we find that these wires have considerably higher sheet resistance than conventional Ga implants and often show non-linear I-Vs. Concurrently, our analysis of the transport properties of these wires shows variable range hopping (in conjunction with the Efros-Shklovskii Coulomb gap) to be the most likely conduction mechanism at low temperatures. Our focus is determining whether high-conductivity, ohmic wires can be realized at liquid He temperatures by varying implant densities and annealing conditions. In addition to transport measurements, we also obtained AFM images to investigate surface morphologies after implantation and annealing. This work is supported by NSF-NIRT and the Molecular Foundry at LBNL.

3:20pm **NS-TuA5 Towards Nanowire-Based Thermocouple Arrays***, M.E. Bourg, R.M. Penner,* University of California, Irvine

The ability to accurately measure temperature on the same time scale as a thermal process under investigation is important in many industrial processes. A thermocouple, which consists of a junction between two dissimilar metals, is most often the device used for such measurements. As the thermal mass of the junction decreases, the response time decreases and the spatial resolution increases. Therefore, junctions containing nanowires should lead to faster response times and increased spatial resolution. In order to initally investigate this, we prepared nanowire-thin film (NWTF) junctions consisting of electrodeposited nanowires and an evaporated film. These devices measure temperature accurately and reproducibly, and have a response time of 2ms. For comparison, the response time of a 0.81mm type J thermocouple was 12s. To improve upon the enhancements shown by NWTF devices, nanowire-nanowire junctions were also fabricated. The characterization of these thermocouple arrays by SEM, EDS, and thermal measurements will be presented.

3:40pm **NS-TuA6 Electrical Properties of Graphene Ribbon Transistors***, Z. Chen,* IBM T.J. Watson Research Center*; X. Du,* Rutgers the State University of NJ*; M.J. Rooks, Ph. Avouris,* IBM T.J. Watson Research Center

Carbon nanotube has caught much attention due to its exceptional physical properties and potential for future nano-electronic applications. Graphene, a single layer of graphite, has similar chemical composition and crystal structures as the carbon nanotube, while at the same time shows semi-metallic behavior. It is proposed that, with intentional size and edge control graphene ribbons can be fabricated and viewed as an unrolled single wall carbon nanotube. The important question however is, whether the right boundary conditions can be introduced to generate quantization and result in semiconducting band gaps. Here we present a study on the electrical properties of the graphene ribbon transistors with various widths. Edge modification and measurements under different conditions will be discussed as well.

4:00pm **NS-TuA7 Superconducting Proximity Effect In Graphene***, X. Du, E.Y. Andrei,* Rutgers University*; A.F. Hebard,* University of Florida

Graphene, a single atomic layer of graphite, has drawn great interest recently both in its unique physical properties and potential for electronics applications. Graphene is an ideal 2D semimetal, with linear dispersion (Dirac Fermion). When in contact with superconductor, many interesting questions arise, in terms of 2D superconductivity and Andreev reflection at the superconductor/relativisitc Dirac Fermion interface. Here we present experimental study on gate controlled superconductor/graphene devices. Electric field dependent superconducting proximity effect and Andreev reflection will be discussed.

4:20pm **NS-TuA8 Catalytic Nanodiode; Chemical Sensing of Gas Phase Catalytic Reaction by using Hot Electron Flows at Metal-Oxide Interface***, J.Y. Park,* University of California, Lawrence Berkeley National Laboratory*; J.R. Renzas, A.M. Contreras,* University of California, Berkeley*; G.A. Somorjai,* University of California, Lawrence Berkeley National Laboratory

Atomic or molecular processes in metals can generate a pulse of hot electrons with kinetic energy of 1-3 eV, and mean free path of the range of ~10 nm. The flow of these hot electrons are directly measured during the platinum catalyzed oxidation of carbon monoxide across a Pt-TiO@sub 2@ and Pt-GaN Schottky nanodiode that were constructed from Pt film, oxide layers, and Ohmic contact pads. The thickness of Pt film used as the catalyst was 5 nm, less than the electron mean free path, resulting in the ballistic transport of hot electrons through the metal. By heating the nanodiodes in He, we could measure the thermoelectric current that is in the opposite direction to the flow of the hot electron current. We found that the chemicurrent was well correlated with the turnover rate of CO oxidation separately measured by gas chromatography, suggesting the possibility of application as chemical sensors with high sensitivity. Chemicurrent measured through the metal-oxide interface remains stable for over several hours and is reversible upon temperature change. The influence of the flow of hot charge carriers on the chemistry at the oxide-metal interface and the turnover rate in the chemical reaction will be discussed.

4:40pm **NS-TuA9 Hydrogen Detection NEMS Devices Fabricated from Tunable Microstructure Pd-Ta-X Nanocomposites***, C. Gilkison, C. Ophus, R. Mohammadi,* University of Alberta, Canada*; Z. Lee, V. Radmilovic, U. Dahmen,* NCEM, Lawrence Berkeley National Laboratory*; D. Mitlin,* University of Alberta, Canada

Macro and micro-scale portable Pd-based resistive hydrogen sensors are considered an established technology. However, because hydrogen needs to both dissociate at the Pd surface and diffuse into the material in a significant quantity, existing portable Pd sensors suffer from relatively slow response times coupled with the requirement of high hydrogen partial pressures for detection. The difficulty in achieving nano-scale sensors, which are intrinsically faster and more sensitive, is related to the difficulty of reproducibly depositing, patterning, etching and releasing very thin Pd lines with high surface to volume ratios. We have developed a family of new thin films based on the Pd-Ta-X (where X is one or more alloy additions) system that have an amorphous-nanocrystalline microstructure. This microstructure is unique and results in materials with exceptional properties including little or no deposition shadowing effects, near atomic level smoothness, very high nanoindentation hardness coupled with ductility, a tunable elastic modulus, metallic conductivity and the ability to still dissociate and absorb hydrogen. These unique features of the Pd-Ta-X nanocomposites have allowed us to fabricate resistive hydrogen sensors with nano-scale width and thickness, but a meter-scale total length, all contained within a micron scale device on a silicon substrate. The combination of a short diffusion length and ultra-high surface to volume ratio has resulted in exquisite detection sensitivity and a very fast response time in these devices. The sensors are strong enough to be partially released from their substrates effectively doubling their surface area to volume ratio, and are easily functionalized to be hydrophobic. We were also able to use these alloys to fabricate the first generation of fully released single-anchored nanometer scale cantilevers, to be used in both static and resonance gas detection mode.

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