POSTER SESSION 2

Balcony, Easel 94

12:45 PM to 2:15 PM

Compositional Optimization of Reduced Polycrystalline $Sr_xBa_1 - xNb_2O_6$ for High-Temperature Thermoelectric

Kyle Forrest Staples, Senior, Materials Science & Engineering
Mary Gates Scholar
Kimbrelle Shey (Kimbrelle) Thommasson, Fifth Year, Materials Science & Engineering
An H. Dang, Senior, Materials Science & Engineering
Mentor: Fumio Ohuchi, Materials Science and Engineering
Mentor: Christopher Dandeneau, Materials Science and Engineering

For thermoelectric (TE) applications, oxides possess certain advantages over conventional intermetallics, including excellent high-temperature stability, low toxicity, and a complex structure, which aids in lowering the thermal conductivity. Recently, it has been found that SrxBa1-xNb2O6 (SBN) holds potential for use in high-temperature TE applications (e.g., waste heat recovery). In our work, a solution combustion synthesis (SCS) process was devised to fabricate SBN with a range of Sr:Ba ratios in order to ascertain an ideal SBN composition for optimum TE behavior. The SCS method, which is highly amenable to mass production, allowed for good control of the SBN stoichiometry, and the as-processed powders were found to possess good single phase purity. Powders processed with different SBN compositions were subject to conventional sintering followed by reduction. The TE properties of each SBN composition were then tested and compared. Preliminary results of our acquired data suggest a decrease in the thermal conductivity as the Ba content is increased, likely due to the larger mass of Ba when compared to Sr. From the obtained results, an ideal SBN composition was determined having the optimal TE performance. Field assisted sintering (FAST) was then employed to processed SBN powder having the optimum composition, and the TE properties of the SBN from both conventional sintering and FAST were compared.

POSTER SESSION 2

MGH 241, Easel 140

12:45 PM to 2:15 PM

Electrical Conductivity Analysis of Graphene Doped with Amino Acids and Self-Assembled Peptides

Richard James (Richard) Boice, Senior, Mat Sci & Engr: Nanosci & Moleculr Engr
Mary Gates Scholar, NASA Space Grant Scholar
Mentor: Fumio Ohuchi, Materials Science and Engineering

This investigation focused on the unique electrical behavior of exfoliated graphene; planar sheets of carbon atoms stripped from bulk graphite flakes. Specifically, the doping effect from self-assembled monolayers (SAMs) on the graphene surface was examined. Previous research has found that certain peptide SAMs are capable of influencing the electrical nature of graphene as both n-type and p-type dopants. This phenomenon can likely aid in development of biosensing and "lab on a chip" technologies. Graphene prepared by the scotch tape method was exposed to chemical solutions of tyrosine (Y) and phenylalanine (F) amino acids. These results are compared with the behavior of similarly deposited GrBP5, a peptide sequence selected for its high binding affinity to graphite. To measure the conductivity and current-voltage profile of graphene doped with each material, graphene field effect transistors (g-FETs) were fabricated on a silicon oxide substrate. Previous research has confirmed GrBP5 is a p-type dopant (electron acceptor). Data collected in this investigation suggests that the tyrosine binding group of GrBP5 is likely the electron acceptor, based on its highly similar doping effect. This p-type nature may be due to the aromatic functional group of tyrosine and would be recommended for future investigation. Furthermore, phenylalanine was found to be an n-type dopant, exhibiting a lower magnitude of doping despite its chemical similarity to tyrosine. By understanding the role of specific amino acids in peptide SAMs for g-FET applications, a large range of peptides may be integrated into this technology, leading eventually to novel biosensing devices.

POSTER SESSION 2

Balcony, Easel 110

12:45 PM to 2:15 PM

Determination of Anisotropic Optical Properties for Single Crystal and Thin-Film β-Ga2O3 using Mueller Matrix Ellipsometry

Jessica Ann (Jessica) Tjalsma, Senior, Materials Science & Engineering, Physics: Comprehensive Physics
Mentor: Marjorie Olmstead, Physics
Mentor: Fumio Ohuchi, Materials Science and Engineering

β-Ga2O3 is a transparent conducting oxide that is well suited to ultraviolet (UV) photovoltaics. One application possibility is as a UV energy harvesting device in space, where UV light is much more abundant than solar. Because of the anisotropy of β-Ga2O3, spectroscopic measurements for a full range of polarization with respect to angles of orientation were taken to obtain optical constants. These measurements were made for both single crystal and thin film samples. As expected, the optical constants vary depending on both the sample type and the orientation of the sample. From these data a model was built that is able to identify the orientation of the single crystal samples. The next step is to build a model that will be used to determine thin film thickness of β-Ga2O3 deposited by our group on different known substrates.

SESSION 2D

CURRENT TOPICS IN BIOENGINEERING

Session Moderator: Elain Fu, Bioengineering
231 MGH
3:45 PM to 5:15 PM
* Note: Titles in order of presentation.

A Novel Paper-Based Diagnostic Test with Improved Sensitivity and Usability for Low-Resource Settings

Tinny Liang, Senior, Bioen: Nanoscience & Molecular Engr
Levinson Emerging Scholar, Mary Gates Scholar
Mentor: Elain Fu, Bioengineering

Millions of people in developing countries die from infectious diseases(e.g. malaria and tuberculosis), yet many of these deaths could be prevented if tools for accurate diagnosis were available. The current method for diagnosis of infectious diseases in low-resource settings is the lateral flow test (LFT), which has the appropriate usability (i.e. equipment-free, rapid, and easy to use), but lacks the required sensitivity to have clinical utility for some disease targets. Thus there is a need for diagnostic tools with improved clinical sensitivity and with the appropriate characteristics for use in low-resource settings. I have designed a novel two-dimensional paper network (2DPN), which enables more sophisticated chemical processes for improved sensitivity and usability in low-resource settings. The novel device utilizes commercial enhancement solutions for signal amplification via a metal catalytic reaction to increase sensitivity. The set of reagents and reagent volumes have been optimized for sensitivity and incorporated into a 2DPN assay device, where the programmed delivery of reagents is achieved through the design of the paper geometry and a fluidic on-switch.

POSTER SESSION 3

Commons East, Easel 69
2:30 PM to 4:00 PM

Feasibility of Transferring Gallium Phosphide to Diamond Using PDMS

Edward Payne Roberts, Junior, Mat Sci & Engr: Nanosci & Moleculr Engr
Mary Gates Scholar
Mentor: Kai-Mei Fu, Physics/ECE
Mentor: Nicole Thomas, Electrical Engineering

The overall project that I work in is to see how quantum states can be used to process information. To realize this, we utilize crystal defects in diamond that exhibit quantum properties. We then network the defects using GaP as a photonic waveguide. GaP is used because at the wavelength of the defect, it is transparent and its index of refraction is higher than diamond. My contribution to this project is to investigate the feasibility of using polydimethylsiloxane (PDMS), a material similar to rubber, as a way to transfer gallium phosphide (GaP) on to the diamond. Using PDMS allows the amount of GaP transferred to be easily scaled due to the surface area of PDMS. I will first use more widely available silicon on insulator substrates to develop a general process flow. The silicon will be patterned as 50 by 50 micrometer squares using photo-lithography and plasma etching. The squares are then transferred to a secondary substrate using a PDMS stamp. We expect then to be able to apply the processing scheme developed for silicon to the transfer of GaP onto diamond.

POSTER SESSION 3

Commons East, Easel 71
2:30 PM to 4:00 PM

Biological Sensing using Diamonds

Christopher Lee (Chris) Chen, Junior, Electrical Engineering
Mentor: Kai-Mei Fu, Physics/ECE
Mentor: Michael Gould, Physics

The study of defects (nitrogen-vacancy centers) in diamond may be instrumental in developing better biological sensors that optically detect tagged biological molecules without interfering with natural processes. Using nitrogen-vacancy (NV) centers, our goal is to develop highly sensitive microscopes that detect magnetic fields produced by magnetic nanotags. Since the NV center photoluminescence intensity depends on its spin state, a decrease in photoluminescence will occur when a magnetic field is applied to the NV center. We employ this property in the detection of nanotags. The applications of this research include the study of biological systems, and faster, cheaper and earlier detection of diseases. While performing optically-detected magnetic resonance in NV centers results in high-sensitivity detection of magnetic fields, a reduction in signal occurs when the NV center symmetry axis is misaligned from the instrument's externally applied magnetic field. Helmholtz coils, which produce near uniform magnetic fields, may be used to align the magnetic field to the proper orientation. Two Helmholtz coils, placed on the horizontal plane of our sample, will allow for clearer detection of photoluminescence dips as the magnetic field will be aligned to one of the NV center axis. In this work, we integrate and test Helmholtz coils in our NV based magneto-optical microscopes. This includes the development of electrostatic simulations and a search algorithm for the alignment of the magnetic field, as well as the fabrication of the coils.

POSTER SESSION 3

Commons East, Easel 68

2:30 PM to 4:00 PM

Design of a Waveguide-Cavity System for Efficient Photon Collection from a Quantum Emitter

Chuting Wang, Junior, Exchange - Arts & Sciences
Mentor: Kai-Mei Fu, Physics/ECE

The nitrogen-vacancy (NV) in color center is regarded as a leading qubit candidate in quantum information processing (QIP) since its spin state can be controlled and measured by optical methods. Efficient collection of photons emitted from NV centers is desirable for scalable QIP schemes. In order to achieve this, we design an integrated waveguide-cavity system in the GaP-diamond hybrid material system. GaP ring waveguides and cavities guide light on the surface of diamond and the guided evanescent mode interacts with NV center located 10 nm from the diamond surface. When a transition from the excited state to the ground state occurs in the NV center, light with a particular wavelength corresponding to the difference in the energy levels (637nm for NV centers) will be emitted. This emission is efficiently emitted into the cavity mode when the cavity is on resonance with the NV transition. We present the optical design of a grating-waveguide-cavity system optimized for efficient collection of photons, which is based on computationally intensive numerical simulation of the optical components. For this, we use a finite-difference time-domain simulation of Maxwell's equations (open-source software MEEP). In order to make the simulation process faster, we utilize parallel computing on the Amazon cloud. We expect to show that theoretical coupling efficiency greater than 50% is possible in the hybrid GaP/diamond material system.

POSTER SESSION 3

MGH 241, Easel 162

2:30 PM to 4:00 PM

Research Experiences with an Ongoing Project about Musical Experiences of Residents in a Retirement Community

Marianne Unite, Senior, Biology (General), Nursing
Mentor: Basia Belza, Biobehavioral Nursing & Health Informatics
Mentor: Musetta Fu, School of Nursing

Healthy aging is influenced by social and physical activities in which older adults participate. Musical activities such as singing, listening to music, and/or playing instruments may serve as an accessible and low cost activity to provide benefits to older adult health. The purpose of the parent study was to learn older adults' insights about music and singing. Informants were recruited from an independent-living retirement community in the Puget Sound. Four resident focus groups were conducted with 20 open-ended questions with topics related to their first images of singing, how do they feel when they sing, and their insights of group-singing. The purpose of this study is to describe the lessons learned in assisting with recruitment, data collection and analysis of data from the parent study. Recruitment efforts varied and included flyers distributed to residential units, telephone calls, announcements before residential meetings, and word of mouth. Running focus groups required training of all research staff, adequate personnel to lead and take notes at the focus group, and adherence to IRB regulations. Analysis of qualitative data required training for the identification of themes. A model was developed and included positive and negative memories from structured and unstructured childhood experiences such as their mothers singing to them, participation in music class, and religious services. Psychosocial, cognitive, and physiological outcomes were identified from their past and current musical experiences, and are supported by the literature. Maintaining good communication and collaboration with the staff in the community was a crucial factor of the successful recruitment and arrangement for the focus groups. The findings of working in collaborative teams through discussion, negotiation, and brainstorming for processing the information, and establishing a community partnership have important implications for future health science research that is conducted in the community setting.

POSTER SESSION 3

Commons East, Easel 79

2:30 PM to 4:00 PM

A Novel Valving Method for Delaying Fluid Transport in Paper Networks

Brittney Aquaila Mc Kenzie, Senior, Bioengineering
Mary Gates Scholar, NASA Space Grant Scholar
Mentor: Elain Fu, Bioengineering

There are many challenges to creating high performance diagnostic tests for use in low resource settings. One approach is to use a paper network format. These paper networks operate by capillary flow and do not require dedicated instrumentation for transporting fluids in them. However, in order to carry out more advanced, multi-step, processes in these networks there is a need for well-characterized paper fluidics tools to precisely control fluid transport within the networks. To address this need, we have designed and characterized a cellulose valving mechanism to produce precise fluid delays, over a wide range of delay times, in both a bench-top system and a disposable card format with less than 10% variability in reproducibility. We achieved this by systematically investigating the effects of valve parameters such as valve dimensions and materials, on the delay time and reproducibility. Finally, the cellulose valves are demonstrated in a paper network card that can automatically sequentially deliver a series of fluids.

Poster Session 3

Commons East, Easel 70

2:30 PM to 4:00 PM

Measuring the Spin Relaxation Time of Donor-Bound Electrons in Indium Phosphide

Pasqual B (Pasqual) Rivera, Fifth Year, Physics: Comprehensive Physics
NASA Space Grant Scholar
Mentor: Kai-Mei Fu, Physics/ECE

Neutral donor-bound electrons and excitons in bulk semiconductors provide a system that may have interesting prospects for quantum information processing (QIP). In GaAs, the donor-bound exciton system exhibits extremely high optical homegeneity with spin relaxation times similar to that of negatively charged quantum dots. The complex excited state structure, however, makes full coherent optical control of the spin state challenging. Exhibiting a simpler excited-state structure and a higher exciton binding energy than GaAs, coherent optical control of donor-bound electron spin states in InP may be more accessible. In this work we investigate the spin relaxation properties of donor-bound electrons in InP using continous wave polarized laser spectroscopy at liquid helium temperature. Current progress towards measuring the spin relaxation time via polarization-induced optical pumping will be presented.

Poster Session 4

MGH 241, Easel 131

4:15 PM to 5:45 PM

Dissolvable Bridges for Manipulating Fluid Volumes in Porous Membrane Networks

Jared Scott (Jared) Houghtaling, Senior, Bioen: Nanoscience & Molecular Engr
Mary Gates Scholar
Mentor: Elain Fu, Bioengineering

Porous membrane-based lateral flow assays have become extremely popular for their inexpensive and user-friendly diagnosis of many conditions. However, commercial lateral flow assays typically only run single-step processes that may lead to inaccurate results for low concentration analytes. Our goal is to create more sophisticated assays that can perform automated multi-step processes to achieve higher sensitivity detection. In order to achieve this goal, porous fluidic valves for the precise regulation of fluid flow in these devices are needed. We have developed a simple shut-off valve that passes a well-defined volume of fluid before permanent shut-off. These dissolvable bridges offer a way to automate the metering of reagent volumes that would otherwise require the user to pipet exact volumes into the device. We have characterized the operation of the valves and demonstrated their tunability using parameters such as geometry and composition of the dissolvable bridge. In addition, we have demonstrated the utility of dissolvable bridges in the important context of automated delivery of multiple volumes from a common source to different locations in an assay for simple device loading and activation. Dissolvable bridges have the potential to help bring advanced testing using porous membrane networks to limited-resource settings.

Poster Session 4

MGH 241, Easel 137

4:15 PM to 5:45 PM

Effects of miRNA Treatment on Migration and Invasion of U-87 Glioblastoma Cells

Sofie Alice Bluvstein, Senior, Biochemistry, Biology (Physiology)
Howard Hughes Scholar
Mentor: Nathan Price, Institute for Systems Biology
Mentor: Cory Funk, Institute for Systems Biology

Glioblastoma Multiforme, the most prevalent form of primary brain tumors, is characterized by its aggressive, invasive nature and short patient lifespan post-diagnosis - approximately 12 months. Through gene analysis of RNA sequencing data, we have found two miRNAs, miR-149 and miR-181, that target gene products whose increased expression has been shown to promote invasion and migration of U-87 human glioblastoma cells. miRNAs are short, non-coding RNAs that bind to messenger RNAs (mRNAs) - the body's method of transferring genetic information, and target them to be degraded or prevent them from being translated into protein. As the miRNAs and the genes are inversely related, treatment of U-87 cells with the miRNAs would cause a decrease in migration, and blocking the miRNAs would cause an increase in migration. To quantify migration, we have employed a scratch test or wound healing assay, in which glioblastoma cells are grown on a dish and the middle of the plate is scratched, leaving space for the cells to migrate. The cells are treated with the miRNAs, and the percent of the gap filled after 24 hours is measured. We expect changes in miRNAs to affect the amount of migration in the gap compared to control - providing evidence that these miRNAs inhibit migration. miRNAs have been investigated as markers for disease, and the presence or absence of this miRNA in a patient's glioblastoma may have implications as to the severity of their case. Additionally, characterizing these miRNAs adds to the database of knowledge concerning glioblastoma. The more that is known about this disease, the closer scientists are to finding a practical treatment.