THE UNIVERSITY OF ARIZONA
GRADUATE COLLEGE

Undergraduate Research Opportunities Consortium

UROC

Abstract Review

August 2015

Integrated Optics for Undergraduate Native Americans

Principal Investigator: Allison Huff MacPherson, PhD

Coordinators: Ameé Hennig, Danny Lamoreaux

UA is the lead institution for the NSF Engineering Research Center, The Center for Integrated Access Networks (CIAN). The Integrated Optics for Undergraduate Native American (IOU-NA) REU program inspires undergraduate Native American students to pursue their goals in STEM research by having students work collaboratively with faculty, graduate students, and other professionals on research projects.

Research projects were conducted in optics and photonics, hydrology, atmospheric sciences, and soil sciences. As part of the program, students were introduced to Native American professionals and graduate students pursuing similar goals, research, and work in industry, and participated in workshops that focus on understanding and performing research on reservations. Students who participated in this year's IOU-NA identified with 7 different tribes.

Christian Bartholomew

Integrated Optics for Undergraduate Native Americans
Port Gamble S'Klallam Tribe

Southwest Indian Polytechnic Institute

Albuquerque, New Mexico

PI: Dr. Krishna Muralidharan

SYNTHESIZING ACTIVATED CARBON FROM PINE CONES

Abstract: **Activated carbon is used in batteries, supercapacitors, and filtration units.** The purpose of this research project is to derive activated carbon by pyrolysing and then activating biomass using a chemical process. The goal is to show the process of converting cheap biomass, in this case from pine-cones, to produce activated carbon. After collecting, cleaning, and breaking down the pinecones to a powder, they are dried in the lab at 110 degrees Celsius, and then treated with the activating agent KOH. The pyrolysis process occurs at 700 degrees Celsius for 2 hours. Once completed, the powder is washed with .2M of HCI and then with DI water until a ph of 7 is attained. The powder is then dried. This chemical activation results in a high conversion yield (40%) of activated carbon from the pine-cones. This research shows that activated carbon can be attained using a very inexpensive and abun-dant material, which represents a sustainable method for obtaining activated carbon.

Conrad Begay

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Navajo

Navajo Technical University

Crownpoint, New Mexico

PI: Dr. Kaushik Balakrishnan

AQUEOUS EXFOLIATED GRAPHENE FOR SUPERCAPACITOR ELECTRODES

Abstract: Supercapacitors belong to the electrochemical energy storage devices that includes batteries and fuel cells. Carbon based materials are widely employed as electrodes in electric double layer capacitor (supercapacitors) owing to unique structural and physical properties such as high surface area, porosity, and electrical conductivity. The recent materials advances towards achieving high quality nanocarbon structures such as carbon nanotubes and graphene have further fueled immense interest for their use in energy storage applications. Indeed, the high surface area of graphene (~2300 m2g-1) along with high conductivity is attractive characteristics to serve as electrodes or additives for the current generation of activated carbon (~800-1200 m2g-1). However, a major challenge lies in improving the yield of the process. In this project, we explored the liquid exfoliation of graphite using sodium cholate as intercalating agent to produce improved yields of few-layered graphene from three different sources of graphite. Optimization of the method revealed that starting concentration of graphite and the sonication time are two of the critical factors. The few-layered graphene suspensions produced from the different sources were found to be highly stable in water with qualitative yields higher than those observed in pure solvents such as N-methyl pyrrolidone (NMP). Furthermore, we attempted to fabricate electrodes based on pure graphene and composites using special binders with activated carbon for use in supercapacitors.

Galveston Begaye

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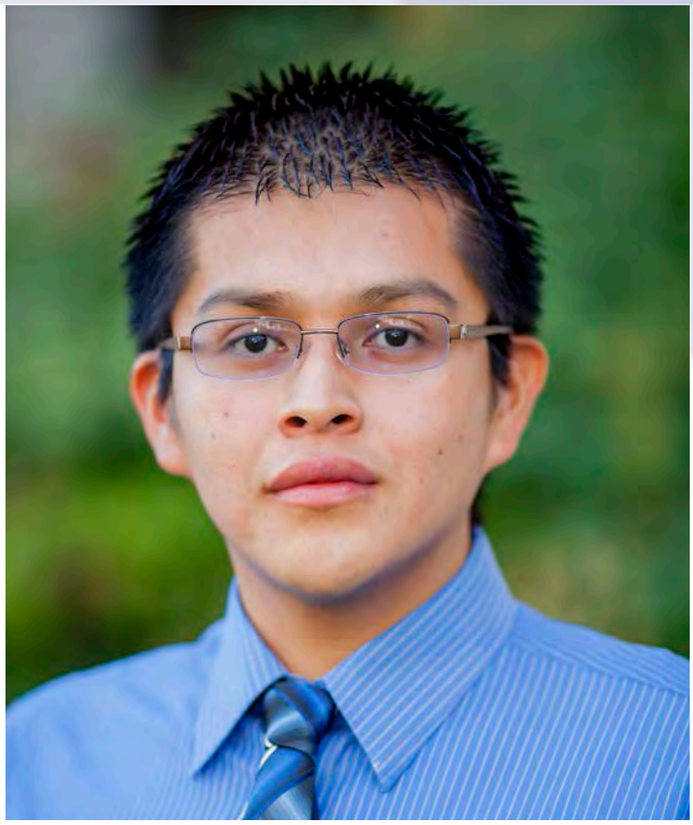

Fort Lewis College

Durango, Colorado

PI: Dr. Thomas Meixner

CHANGES IN DOM QUANTITY AND QUALITY IN A SOUTHERN ROCKIES FORESTED CATCHMENT

Abstract: When forest fires occur, shifts in ecosystem structure can have a significant impact on ecosystem function. One potential impact of forest fire is a shift in processes governing Dissolved Organic Matter (DOM). DOM is a key control on water quality and DOM provides nutrients that are consumed by the surrounding ecosystem. In order to investigate how DOM in the hydrologic system is impacted by a forest fire, data from two catchments in the Valles Caldera National Preserve will be examined. After a forest fire occurs, is there a significant impact on the ecosystem and DOM? If so, how will DOM characteristics vary when compared to the actual observations after a forest fire? This study seeks to understand what controls DOM quantity and quality. The product of the fractions of each endmember and the corresponding DOM concentration and quality indices, a calculated value of DOM and the indices are obtained. The data are interpreted as a distribution and not a pure average by creating histograms to plot data against time to understand underlying variability. If there is a high correlation between the calculated and observed values, then the DOM comes from the mixing of waters, if not then some other biogeochemical process is altering its concentration. The TOC observed and predicted ratios from graphs, depict that the TOC is being consumed from the source waters to the stream. In addition, the graphs show there is greater OM decomposition and high aromaticity that creates greater DOC reactivity. In other words HIX and SUVA are behaving differently than FI. As for the FI data depicted from the produced graphs, the FI from the source waters were determined to be terrestrially derived.

Robert Castellanos

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Colorado River Indian Tribes

Northern Arizona University

Flagstaff, Arizona

PI: Dr. Pierre-Alexandre Blanche

2-DIMENSIONAL PUPIL EXPANDER FOR HEAD-UP DISPLAYS

Abstract: Waveguide technology for head-up displays (HuD) in aircrafts has the ability to replace conventional HuD technology due to their having a larger eye-motion box allowing for a larger field of view. Conventional HuDs use a projector system to display an image on to a semi-transparent glass screen, the combiner. However they require the use of lenses to be housed overhead in an avionics bay within the cockpit. The image displayed on the combiner is directly proportional to the size of the lenses needed. Waveguide HuD technology can be integrated into smaller avionic systems by reducing the number of lenses necessary to display an image while maintaining pupil size. Pupil expansion occurs within the waveguide allowing for smaller optics needed to scale an image. The output image being scaled up can then have a much larger viewing screen for increased pilot comfort. Utilizing holographic diffraction gratings, it is possible to inject and then extract an image from the waveguide system with holograms. Injected light is contained within the waveguide due to total internal reflection. Recording an injection hologram under proper conditions will cause a beam of light to be injected into the waveguide system and have expansion occur simultaneously in 2 dimensions. However, the results from implementing such a system have shown that the image aberration produced are too large to be used as a head-up display. Future investigation directions will look into image expansion one dimension at a time through a waveguide.

Brandon Ryan Jesus

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Durango, Colorado

PI: Dr. Eric Betterton

INVESTIGATING LEAD AND ARSENIC EXPOSURE RISKS TO A COMMUNITY AREA THROUGH ANALYSIS OF AIRBORNE PARTICLES ON CHILDREN'S PLAYGROUND SURFACE EQUIPMENT

Abstract: Exposures to lead and arsenic from airborne contaminants near mining and smelting operations can occur through many exposure pathways. This study was carried out to determine the risk of exposure from deposition of lead and arsenic on surfaces that regularly come in contact with human hands. Fine particulate matter containing lead and arsenic can be produced through grinding, smelting and concentrating of ore, airborne lead and arsenic can also originate from resuspension of particles from tailings impoundments. These ultra-light toxic aerosols can be transported via wind and settle in and near surrounding communities resulting in detrimental effects for nearby populations and ecologies. Over time lead and arsenic can accumulate on stationary objects such as children's playground equipment. For growing children lead exposure is a severe health hazard that can lead to complications such as stunted growth and learning disabilities. A study was carried out to determine the extent of lead and arsenic deposition on children's playground equipment in Hayden-Winkleman, Arizona, the site of the ASARCO copper smelter and ore processing plant. The study was implemented following a strict protocol from a similar study out of Port Pirie, Australia. Results from the study revealed significantly higher Lead and Arsenic levels on the playgrounds located next to mining operations as compared to background samples taken at playgrounds in Tucson, AZ.

Vernon Michael Kaye

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PI: Dr. Khan Kieu

MULTIPHOTON WRITING

Abstract: Multiphoton writing is a technique used to focus a 1550 nm femtosecond laser to a spatial measurement of a few nanometers which will alter the physical characteristics of the photoresist polymer to create a three dimensional object at a nanoscale. The current issue of the multiphoton writing can be seen in the post exposure treatment of the sample which does not maintain proper adhesion to the substrate. Therefore through proper clean room procedure substrate cleaning is the first and a very important step in any lithographic process, as the adhesion of the resist to the substrate could be compromised by the presence of any impurities in the air and other remaining contaminates. The results have been unsuccessful as the sample is still unable to maintain adhesion to the substrate during the post exposure process. However the technology itself has shown promise as it is able to create three dimensional objects at a nanoscale. With more experimentation of polymer development the sample might see better results.

Desiree A. Saraficio

Integrated Optics for Undergraduate Native Americans
Tohono O'odham

Tohono O'odham Community College

Sells, Arizona

PI: dr. Jim Schwiegerling

SMARTPHONE-BASED OCULAR IMAGE

Abstract: An estimated 285 million people worldwide exhibit some form of visual impairment. Impairments such as blindness, low vision or visual defects are relatively high. Importantly, 80% of global blindness is a direct result of five preventable or treatable conditions. Conditions of high interest are corneal opacity, trachoma, and corneal trauma. These conditions affect the visual clarity of the cornea. Significant amounts of the affected people reside in rural areas within Africa and Asia. To increase resources, our objective was to design and fabricate an optical system that attaches to a smartphone camera. By utilizing the image quality, mobility and availability of cellphone cameras, a telecentric optical system was designed and housed in a 3D printed cellphone adapter, which the camera images the cornea through. The optical components consist of two doublet lenses and a beam splitter. A tunable visible-LED was placed above the beam splitter, reflecting 50% of the light to the cornea and transmitting 50% through to illuminate a ruler. The camera captures an overlaid image of the cornea and ruler, providing a means to measure the eye and pupil diameter. The system was firstly tested to validate the position of maximum contrast with different wavelengths and target distances. Secondly, images were taken of a 2D and 3D eye model. By doing these tests we were able to determine the system's dynamic range and pupil diameter accuracy of the 2D and 3D structured models. The maximum dynamic range was 3 mm and the pupil diameter measurements were 98.76% accurate.

Lisa J. Willis

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PI: Dr. Palash Gangopadhyay

ALIGNED CARBON NANOTUBES IN SUPERCAPACITORS: CAN THIS BE A COST EFFECTIVE SOLUTION?

Abstract: Our plan was to determine a cost effective solution comparing inexpensive nanotubes to other commercially available nanotubes for cost efficiency. A handful of different carbon nanotubes: metallic, semiconductor and mixtures, were compared by cost per gram and by the purity of the product. We synthesized a polymer composite using PMMA and ~2 wt% of each of the 4 different carbon nanotubes studied. Next we added a plasticizer during the film fabrication so that the composite can be melted at relatively lower temperature. A rotating poling chamber with a magnetic field was used to align the carbon nanotubes embedded within the films vertically, horizontally and at a 45º angle with respect to the substrate. We tested the films by the use of absorption spectroscopy, surface resistivity measurements, electrostatic force microscopy and polarized Raman spectroscopy. Absorption spectra were used to test their compositions in the composite films. The surface resistivity of all films was measured using 4-probe measurement technique. We used electrostatic force microscopy to probe and map sub-surface carbon nanotubes buried inside electrically insulating PMMA. The polarized Raman spectroscopy was used to compare alignment efficiency and quality of each type of nanotubes. Our findings indicate that the inexpensive nanotubes are just as reliable as and may be even better than the purified semiconductor and metallic single wall carbon nanotubes. Future work using TUBALL single wall carbon nanotubes will be very cost efficient. We are also looking into using TUBALL nanotubes to recreate last year's 3D nanostructured carbon electrodes for supercapacitor applications.

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SUMMER RESEARCH INSTITUTE (SRI)
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Sponsor: NIGMS/TWD Division GM 08718

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CIAN INTEGRATED OPTICS FOR UNDERGRADUATE NATIVE AMERICANS (IOU-NA) RESEARCH EXPERIENCE FOR UNDERGRADUATES
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Coordinator: Ameé J. Hennig, Daniel Lamoreaux
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Sponsors: National Science Foundation Research Experiences for Undergraduates Program.

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