THE UNIVERSITY OF ARIZONA
GRADUATE COLLEGE

Undergraduate Research Opportunities Consortium

UROC

Abstract Review

August 2015

Hooked on Photonics

Program Co-Director: Nasser Peyghammbarian, PhD
Program Co-Director: Neal Armstrong, PhD, PI

Coordinator: Ameé Hennig
Coordinator: Danny Lamoreaux

Hooked on Photonics (HoP) is a 10-week summer research program for undergraduate students studying chemistry, physics, materials science, engineering, or optics. Research sites are located at three universities: University of Washington in Seattle, University of Arizona in Tucson and the Georgia Institute of Technology in Atlanta.

In contrast to electronics, which deals with the transfer and storage of information using electricity, photonics involves the use of light to control, transmit and manipulate information.

Advances in the science of photonics have the potential to vastly increase available bandwidth, allowing for ultra-fast communications over a new optically based network. HoP researchers are working on the leading edge of these new technologies: light emitting diodes, photovoltaic cells, nano-fabrication, transistors, and optical switching devices.

Shoujit Banerjee

Hooked on Photonics

University of California, Berkeley
Berkeley, California

PI: Dr. Khahn Kieu

Biological Imaging with Spectral Domain Optical Coherence Tomography (SD-OCT) at 1040 nm

Abstract: The integration of optical devices in a clinical environment can lead to greater success in early detection of disease as well as improved efficiency in patient care. The aim of this research is to design and construct a Spectral Domain Optical Coherence Tomography system that is capable of imaging biological tissue, and subsequently in helping determine tumor margins during surgery. The input source of the system is a broadband 1-micron ASE laser (λ_0 = 1040 nm, $\Delta\lambda$ = 120 nm). Light is directed into a 50/50 fiber splitter, which splits the light evenly into the sample and reference arms. The sample to be imaged is placed in the sample arm, whereas the reference arm consists of a silver-coated mirror. The entire system is carefully aligned to ensure high-contrast interference between the backscattered light from the sample and mirror surfaces. A spectrometer system, which consists of the collimator, diffraction grating, focusing lens, and CCD array, detects the interference signal in the spectral domain. After post-processing, the resulting image shows the tissue layers in the sample. This device was initially calibrated using a coverslip, and then tested on multiple biological samples, including onion peels, the distal end of a human fingernail, and pancreatic tissue. From these images, tissue layers and cell structures were visible at depths of up to 0.6 mm. With further research, the penetration depth of the system should be increased to beyond 2 mm, and the system may be combined with other optical imaging techniques, such as multiphoton microscopy.

James Elmer Keener

Hooked on Photonics

University of California, Merced

Merced, California

PI: Dr. Clayton Shallcross

INTEGRATION OF DOPAMINE/POLY(DOPAMINE) SELF-ASSEMBLED MONOLAYERS (SAMS) TO MODIFY THE SURFACE ENERGY OF PEROVSKITES

Abstract: Due to the recent growth in concern for environmental issues and the ever-growing demand for sustainable energy, sources of renewable energy such as solar cells have become the focus of significant research efforts. In the past few years, hybrid organic-inorganic perovskite solar cells have garnered considerable recognition as promising devices capable of providing a low-cost and highly efficient source of renewable energy. Herein, we explore the effect of adsorbing dopamine derivatives (dopamine hydrochloride and poly(dopamine)) onto chemical vapor deposition-deposited TiO2 substrates as interfacial layers for methylammonium lead triiodide (MAPbI3) hybrid perovskite solar cell materials. These interfacial modifiers were expected to control TiO2 surface energy and, thus, morphology of the subsequently deposited perovskite layer; where the end functional amine group was envisioned as a complementary substrate modifier due to its close proximity to ammonium substituents in the perovskite active layer. Atomic force microscopy (AFM) results revealed larger perovskite crystal size in dopamine functionalized TiO2 compared to non-functionalized TiO2, indicating a potentially advantageous change in TiO2 surface energy. Poly(dopamine) functionalized TiO2 yielded smaller contact angles (water) than bare TiO2, suggesting improved wettability. Further research is necessary to elucidate the viability of dopamine and poly(dopamine) as interfacial modifiers that may enhance the morphology and performance of hybrid perovskite solar cells.

Rachel Allison Sampson

Hooked on Photonics

Stony Brook University

Stony Brook, New York

PI: Dr. Pierre-Alexandre Blanche

REALIZATION OF A DIFFRACTION-BASED 1XN OPTICAL SWITCH

Abstract: A 1x100 diffraction-based optical switch was designed for use in data centers. The switch decouples the send- and receive-side components, allowing for independent scaling of the two sides, is bandwidth-invariant, and has a rapid reconfiguration time [12 µs]. These properties combine to create a robust technology capable of adapting to the rapidly changing demands of data centers.

In the switch, 1550 nm laser light is shone onto a digital micromirror device (DMD). The DMD acts as an active steering unit and diffracts incident light at some precalculated angle using computer generated holograms. The DMD however has a limited angular range, which translates into a restricted spatial span. To increase the spatial range of the switch so that all racks within the data center can be accessed, a mirror assembly is used. Light diffracted off the DMD hits the mirror assembly and is redirected to the desired destination racks. The angles of the mirrors in the mirror assembly are predetermined so that each mirror connects a source rack to one destination rack. The switch was modeled in Zemax, an optical design program, and serves as a proof-of-concept that 1xN diffraction-based optical switches can be created. Future research will focus on further increasing the number of output ports.

Mark Soliman

Hooked on Photonics

University of Albany

Albany, New York

PI: Dr. Robert Norwood

DIATOM CULTIVATION, STRUCTURE ALTERATION AND OPTICAL IMAGING OF THALASSIOSIRA MARINE DIATOMS

Abstract: Diatoms are algae with the unique characteristic of forming transparent silica based shells; due to diatoms' extremely small sizes it is often difficult to quantitatively classify their optical properties, properties of their silica shells, and the positions of their chloroplasts, the photosynthetic engine of the diatom. The goal of this project is to tune the optical and physical properties of the silica frustule of centric marine diatoms Thalassiosira by selective contamination with a metal pollutant, or other chemical compounds in order to determine whether there is a correlation between the contaminant and such factors as chloroplast position, and silica shell pore sizes. If such a correlation can be established, this could lead to a convenient method of testing water quality by optically imaging diatoms, without necessitating the use of scanning electron microscope (SEM) or other complex imaging techniques to test the quality of the water and the level of contaminants present.

The diatom species Thalassiosira were cultivated in 30 different beakers. The diatoms were exposed to 12 hour light and dark cycles. After cultivation of the diatoms under various different conditions, efforts were made to assess their structure and the location of organelles. Initially optical microscopy was used; but the optical microscope proved ineffective since the diatoms were too small for the optical microscope to locate the chloroplast position or the silica shell. With help of the confocal fluorescence microscope we have been able to locate the chloroplasts, and this technique is now being investigated as a way to image the silica shells.

GRADUATE COLLEGE

Undergraduate Research Opportunities Consortium

PROGRAM STAFF AND SPONSORS • 2015

SUMMER RESEARCH INSTITUTE (SRI)
Coordinator: Donna Treloar, MA
Instructors: Andrew Huerta, PhD, Renee Reynolds, ABD, Joanna Sanchez-Avila
Sponsors: University of Arizona; Graduate College; The Partnership for Native American Cancer Prevention (NACP) training program, a collaboration between Northern Arizona University and the University of Arizona Cancer Center, funded by the National Cancer Institute; College of Medicine – Office of Diversity and Inclusion, Health Resources and Services Administration (HRSA) Centers of Excellence; Western Alliance to Expand Student Opportunities (WAESO); Department of Physics.

MINORITY HEALTH DISPARITIES SUMMER RESEARCH PROGRAM (MHD)
Coordinator: Stephanie Adamson, Holly Lopez
Sponsors: University of Arizona; Graduate College; Western Alliance to Expand Student Opportunities (WAESO).

MAXIMIZING ACCESS TO RESEARCH CAREERS (MARC)
PIs: Megan McEvoy, PhD; Marc Tischler, PhD, Maria Teresa Velez; PhD
Coordinator: Cindy Neal, MEd
Sponsor: NIGMS/TWD Division GM 08718

HOOKED ON PHOTONICS RESEARCH EXPERIENCE FOR UNDERGRADUATES (HOP)
PIs: Nasser Peyghambarian, PhD
Sponsors: University of Washington/National Science Foundation (NSF). Funding for this research was provided by NSF Grant No. CHE-1156598.

CIAN INTEGRATED OPTICS FOR UNDERGRADUATE NATIVE AMERICANS (IOU-NA) RESEARCH EXPERIENCE FOR UNDERGRADUATES
PI: Allison Huff Mac Pherson, DHEd, Robert Norwood, PhD
Coordinator: Ameé J. Hennig, Daniel Lamoreaux
Sponsors: National Science Foundation (NSF) Engineering Research Center for Integrated Access Networks (ERC CIAN). Funding for this research was provided by the NSF Engineering Research Center No. EEC-0812072.

BIOSPHERE 2
PI: Katerina Dontsova, PhD
Sponsors: National Science Foundation Research Experiences for Undergraduates Program.

STUDENT AFFAIRS RESEARCH PROGRAM (STAR)
Coordinator: Nura Dualeh, MA
Instructors: Andrew Huerta, PhD, Renee Reynolds, MA, Joanna Sanchez-Avila
Sponsors: University of Arizona; Graduate College; Division of Student Affairs; Western Alliance to Expand Student Opportunities (WAESO).

UROC-PREP
Coordinator: Donna Treloar, MA
Instructor: Andrew Huerta, PhD
Sponsors: University of Arizona; Graduate College, Western Alliance to Expand Student Opportunities (WAESO).

CAT VEHICLE PROGRAM/ ECE REU
PI: Jonathan Sprinkle, PhD
Coordinator: Nancy Emptage
Sponsor: National Science Foundation Research Experiences for Undergraduates Program

RESEARCH IN OPTICS (RiO)
PI: R. John Koshel, PhD
Coordinator: Melissa Sarmiento Ayala, MEd
Sponsor: National Science Foundation (NSF) Award No. 1460723.

UROC GRADUATE COLLEGE
Undergraduate Research Opportunities Consortium