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| **2020 Boston University ECE Summer Research Projects** |
| Project title | Project Description | Mentor | openings |
| Photoacoustic interface for cell modulation  | We aim at developing photoacoustic devices, materials and scaffolds to enable modulating cellular activities, such as delivery of gene, activations of neurons, promoting regrowth for tissue regeneration. Specifically, we are focus on generate acoustic signals upon the excitation of near-IR to stimulate brain. In this study, we have the goal of controlling of acoustic frequency generated. Such study will enable understanding on whether different types of neurons respond to different acoustic frequencies and lead to non-invasive selective and multiplexing stimulation of neurons in brain.  | Chen Yang | 2 |
| Responsive Nanofluidics through photoacoustic functions. | Photoaccoustic nanoparticles can be embedded in polymer materials to provide stimulation function for the biomaterial for tissue generation purpose. We will extend our study to develop responsive nanofluidics channels using photoacoustic nanoparticles to precisely control fluid at the nanoscale channel. This approach will provide unique platform for sorting and analyzing in biotechnology and pharmaceutical industry.  |
| Development of nano-CARS with 10-nm resolution | Development of nano-CARS with 10-nm resolution through tip-enhanced coherent anti-Stokes Raman scattering (CARS) on a biological atomic force microscope. Such resolution will enable new understanding of molecular machinery inside a living system. The student will be mentored by a postdoc in this area.  | Ji-xin Cheng | 2 |
| Ultrasensitive chemical imaging | Ultrasensitive chemical imaging at single molecule level by plasmon-enhanced stimulated Raman scattering. This project is built upon our pilot study published in nature communication in 2019. This student will be mentored by a postdoc in this area.  |
| 3D chemical phase microscopy | This project will integrate mid-infrared excitation and intensity diffraction microscopy to realize infrared chemical imaging and 3D submicron spatial resolution. The student will be supervised by a postdoc in this area. A pilot study was published in Light S&A in 2019. |
| Multiplex opto-acoustic neural stimulation. | A desired pattern will be created by a DMD and converted into an ultrasound pattern with 20-micron spatial resolution. The final goal is to make blind able to “see” the world via optoacoustic stimulation of retina. The student will be mentored by a research scientist. A pilot study will appear in nature communications in 2020.  |
| Metamaterial Photonic Devices | Typical optoelectronic devices such as light emitters and photodetectors employ external bulk optical elements (e.g., lenses, mirrors, polarizers, and gratings) to interface with free-space radiation, which can severely limit their miniaturization and scalability to high-density arrays.  This project explores a novel approach for the near-field control of light emission and photodetection, based on the use of metasurfaces, i.e., rationally designed arrays of metallic or dielectric nanoparticles of highly subwavelength dimensions.  These nanostructures are designed with full-wave electromagnetic simulations and fabricated in the immediate vicinity of the device active layer using a variety of different techniques, including thin-film deposition, electron-beam lithography, reactive ion etching, and focused-ion-beam milling.  With this general approach, we are developing lens-free image sensors that are uniquely sensitive to light incident along a single, geometrically tunable direction, for the implementation of ultrasmall cameras based on the compound-eye vision modality.  Furthermore, we are investigating the fabrication of highly integrated light-emitting devices where the properties of the output light (including directionality, polarization, and spectral content) can be tailored directly at the source level, without the need for any external optical components. | Roberto Paiella | 1 |
| Light’s Orbital Angular Momentum (OAM) | Light’s Orbital Angular Momentum (OAM), Polarization and its inherent chirality, and its interactions with matter.One of the premier topics in the field of photonics is the study of the topological properties of light, that is, how light’s phase and polarization lead to exotic beams that interact in new ways with matter. Our group’s studies in this area spans from the fundamentals (how does the speed of light change with angular momentum) to applications (how to use OAM to increase bandwidth of telecommunications systems, how to exploit them in quantum communications, and how to exploit them for novel kinds of spectroscopy). Our group is one of the leaders in the field, having invented the first optical fiber in which topological states of light can be transmitted (see<http://dx.doi.org/10.1126/science.1237861> and <http://doi.org/10.1038/s41467-019-12401-4>), and the student(s) involved in this project will have a choice of working on the fundamentals or devices/applications related to this broad area. | Siddharth Ramachandran | 2 |
| Ultrafast lasers for brain imaging | An important tool for studying the neurological connections in the brain is an ultrafast laser, potentially emitting one or more desired colors of desired energies, bandwidths and pulsewidths, and potentially synchronized or time-delayed. This level of complex control usually requires large, bulk lasers that can be used in research, but cannot be transitioned to practice in a clinic or industry. Our group has developed some novel concepts for creating on-demand tunable ultrafast lasers which uniquely satisfy the demands of the biomedical imaging community (see, for e.g.<https://doi.org/10.1364/OPTICA.6.000304>). Student(s) working in this area would have the choice of either learning new concepts in nonlinear optics to develop advanced lasers and devices, or using them with in-house multiphoton microscopes to study imaging with exotic “Bessel beams” (see <http://dx.doi.org/10.1364/OL.36.004671>) that allow deeper, higher resolution imaging that that possible with conventional Gaussian beams. |
| label-free 3D microscopy | This project aims to develop real time 3D label free phase tomography techniques based on intensity only computational imaging approaches.  | Lei Tian | 1 |