Announcing the Final Examination of Muhammad Waqas Shabbir for the degree of Doctor of Philosophy in Physics

Date: 07/08/2021
Time: 11:00 a.m.
Zoom meeting: https://ucf.zoom.us/j/4836596699?pwd=T3YxK2krZ3lESHFNRTBKZk9NRHdKQT09
Meeting ID: 483 659 6699
Passcode: 480381
Dissertation title: Plasmonic properties of nanopatterned graphene.

Abstract:
Graphene is an atomically thin two-dimensional material whose electronic and optical properties are governed by massless Dirac electrons and their linear dispersion around the Dirac points. Graphene exhibits an extraordinarily high electrical conductivity, in fact the highest electrical conductivity of any known material on earth, which would be very useful for ultrafast electronic devices with low dissipation, such as transistors that could operate at much higher frequency.

A major limitation of graphene is its weak light-matter interaction achieving only about 2% absorption of light from the infrared (IR) to the visible regime, which hampers its use for photodetectors, light energy harvesting devices, or plasmonic lasers. An effective solution is to create nanopatterned graphene (NPG) by making sub-micrometer sized holes arranged periodically in a square or hexagonal lattice. By means of electrostatic gating it is possible to shift the Fermi energy of NPG up to around ± 1 eV such that localized surface plasmons (LSPs) around the holes can be excited by mid-IR light in the wavelength regime from 3 μm to 12 μm and beyond with absorption close to 100%.

Using this novel NPG material we studied theoretically several intriguing new phenomena: (i) Dirac plasmon-assisted asymmetric hot carrier generation for room-temperature IR photodetection; (ii) Plasmonically enhanced mid-IR light source based on tunable spectrally and directionally selective thermal emission from nanopatterned graphene; (iii) Plasmonically enhanced spectrally selective narrowband MWIR and LWIR light detection based on hybrid nanopatterned graphene and phase changing vanadium oxide heterostructure operating close to room temperature; (iv) Dynamically tunable extraordinary IR light absorption and emission in multilayer graphene; (v) Multiple resonance IR absorber and emitter based on NPG on slot antenna.

Outline of Studies:
Major: Physics

Educational Career:
M. S. University of Central Florida, 2019
M.Phil. Quaid-e-Azam University, Islamabad, 2010

Committee in Charge:
Dr. Michael N. Leuenberger (Chair)
Dr. Tania Roy
Dr. Madhab Neupane
Dr. Winston Schoenfeld (External Committee Member)

Approved for distribution by Dr. Michael Leuenberger, Committee Chair, on June 23, 2021.
The public is welcome to attend remotely.