**Advanced Terahertz Photonics**

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Terahertz (THz) radiation science is expected to have a significant impact on a wide variety of disciplines that are bound to shape the lives of people in the 21st century. THz waves, whose frequency range is defined roughly to be from 0.1 to 10 THz (or wavelengths from 30 μm to 3000 μm), lies between optics and microwaves. THz waves (i) can penetrate and image inside plastics, semiconductor wafers, fabrics, and most dielectric materials that may be opaque to visible light, (ii) have low photon energies that do not cause harmful photoionization in biological tissue, and (iii) exhibit strong dispersion as well as absorption for numerous molecules. THz technology also employs unique methods that are not found at other frequencies, such as THz time-domain spectroscopy (THz-TDS), which allows the evaluation of the complex index of refraction of materials without resorting to the Kramers-Kronig relation.

Therefore, T-ray imaging and diagnostics have tremendous potential for applications in non-destructive testing and imaging, medical diagnosis, health monitoring, and chemical and biological identification. Over the past two decades, there has been extensive progress in THz technologies, mainly propelled by the rapid progress in ultrafast laser technology and in microelectronics fabrication. For example, recent advances in the generation of intense THz pulses is stimulating new studies in nonlinear THz optics. High-field carrier transport dynamics at THz frequencies in semiconductors can lead to numerous ultrafast phenomena, such as THz pulse self-phase modulation, intense THz field induced impact ionization, as well as dynamic Bloch oscillations driven by ultra-high THz frequencies. In the nonresonant regime, carriers can be efficiently accelerated by the intense THz field, resulting in high ponderomotive energy that is proportional to the square of the peak field and inversely proportional to the square of the THz frequency.

In this talk, I will first shortly review the basics of THz radiation, its generation, detection and applications. Then, I will discuss some of our recent results in nonlinear THz spectroscopy, focusing on graphene and doped semiconductors.