Initial Terahertz Probing of Carbon Nanofiber Composite Coatings as Potential Quasi-Optical THz Shielding and Attenuation Devices

Lei Liu[1*], Tao Wang[1], Abhijit Biswas[1], and Constantine M. Megaridis[2]
1 Department of Electrical Engineering, University of Notre Dame, Notre Dame, IN 46556*
2 Department of Mechanical and Industrial Engineering, University of Illinois at Chicago, Chicago, IL 60607

* Contact: lliu3@nd.edu, phone +1-574-631-1628

***Abstract*— Electromagnetic waves in the terahertz frequency range (0.1 – 10 THz) have remained the least explored and developed in the entire spectrum, thus creating what is widely known as the "THz gap." In recent years, there has been an unprecedented growth in the development of terahertz devices, circuits and systems due to their promising applications in astronomy, chemical analysis, biological sensing, imaging and security screening. THz sources based on Schottky diodes and quantum cascade lasers (QCL) currently provide plenty of output power, covering a broad frequency range. Improvements in transistor technology also have enabled the demonstration of THz amplifiers and integrated circuits up to 300 GHz. It is predicted that THz-based communication systems with data rates of 5-10 Gb/s or higher will replace today's wireless LAN systems in 10 years. With the increasing speed of the above electronic circuits and systems, Electromagnetic interference (EMI) shielding in the THz region is becoming more important. THz EMI shielding may also find applications in security, defense and astronomy to protect information detectable by THz imaging and sensing techniques. In addition, effective THz attenuation devices are required in many quasi-optical systems (e.g. THz spectroscopy and imaging), where not much research has been done to date. Therefore, new innovations in materials and processes for EMI shielding and attenuation of THz electronic devices are of immense interest for a number of advanced technology applications.**

In this paper, we report our initial work on THz characterization of carbon nanofiber (CNF) composite coatings using a room temperature frequency domain terahertz spectroscopy and imaging system. The system was developed on the basis of a broadband quasi-optical zero bias Schottky diode detector. The detector was designed to cover the frequency range of 100 GHz to 900 GHz. A responsivity of 300-1000 V/W has been measured, and the noise equivalent power (NEP) is 5-20 pW/√Hz. The system was calibrated by measuring Mylar thin films and metal mesh filters. For prototype demonstration, several polymer-based large area CNF coatings containing different CNF/polymer weight ratios were characterized in the frequency range of 190-210 GHz, and 570-630 GHz. A THz shielding effectiveness (SE) of ~ 24 dB, and ~ 32 dB, respectively, were measured for the coating with the highest possible CNF content (~ 14 wt%), in the two examined regions. The coating attenuation level can be modified by varying CNF loading content. Two-dimensional distributions of power attenuation of these coatings at 600 GHz have been measured to evaluate the coating spatial uniformity. A coating uniformity of less than 5% has been demonstrated, and the coatings may have high potential for quasi-optical THz shielding and attenuation applications. These CNF coatings also hold the promise for inkjet-printing of light-weighted, cost-effective and flexible THz quasi-optical components such as grid-polarizers and filters.