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Cost-Effective Terahertz Quasi-Optical Components Based on Inkjet Printing of Carbon Nanocomposite Coatings

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***Abstract*—Electromagnetic waves in the frequency range of 0.1-10 THz have remained the least explored and developed in the entire spectrum, creating what is widely known as the "Terahertz Gap". In recent years, THz waves have attracted much attention and continuous interests owning to their prospective applications in many important fields such as astronomy, chemical analysis, biological sensing, imaging and security screening. Among many in-development THz quasi-optical components, THz attenuators, polarizers and filters have been highly demanded in spectroscopy, polarization interferometry, polarimetric detection (e.g. polarization of Cosmic Microwave Background), and other systems. However, conventional methods for realizing the above components usually require complicated microfabrication processes such as photolithography or chemical etching. Therefore, new innovations in materials and processes for cost-effective, and potentially high performance THz quasi-optical components are of immense interest for a number of advanced technology applications.**

In this paper, we report a new approach for making cost-effective THz quasi-optical components based on inkjet printing of carbon nanocomposite coatings. The coating fabrication process is inherently low-cost, and all ingredients are commercially available. The chemical inertness of the coatings along with their water repellency and self-cleaning ability prevent contamination and corrosion when exposed to outdoor conditions. In addition, the patterning of the coatings can be achieved using inkjet-printing, bypassing the complicated photolithography, nanoimprinting, or chemical etching processes, thus holding the potential promise for cost-effective, flexible THz quasi-optical components such as polarizers and filters.

In our previous work, we have demonstrated that large area carbon nanofiber (CNF)/PTFE polymer composite coatings as effective THz shielding and attenuation devices. The coating attenuation level can be modified by varying CNF loading content, and a THz shielding effectiveness (SE) of ~ 24 dB and ~32 dB were measured for the coating with the highest CNF content in the frequency range of 190-210 GHz and 570-630 GHz respectively. For a prototype demonstration, THz polarizers were first designed and inkjet-printed on Mylar thin films with nanocomposite coatings for operation near 600 GHz. The measured transmission, as well as calculated absorbance vary with polarization orientation as expected. An average degree of polarization of 0.35 has been demonstrated over the entire frequency range of 570-630 GHz, for a polarizer with a coating thickness of only 10 µm. The polarizer performance, specifically the extinction ratio, can be potentially improved to be near 60 dB by increasing the coating thickness and adopting dual-layer polarizer structures. Prototype THz filters using single- and cross-slot structures will be soon fabricated for performance evaluation. The manufacture process and measurement results will be presented at the conference.