Next Generation Terahertz mm-Wave Technology and its Applications

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Abstract—The objective of this research is to investigate and propose a pulse-based communication, localization, and imaging scheme. Sub-100 picosecond pulses will be coherently transmitted through multiple transmitters for secure communication and localization. The technique aims at achieving an information beam width of less than 0.1° and an RF imaging system with sub-millimeter resolution. In addition to this, high-speed samplers and transmitters fabricated with advanced CMOS technology will be used, with an overarching goal of building a complete pulse-based communication and localization system.

I. INTRODUCTION

During my undergraduate education, I became fascinated with mm-wave circuits and terahertz research. Terahertz waves, which occupy the band from 0.1 mm to 1 mm, are unique in the spectrum because of their potential applications in secure communications, automotive radar, and medical imaging [1]–[5]. Despite the interest in using terahertz waves, we currently lack the underlying hardware platform to build upon. To solve this problem, I proposed the development of mm-wave and terahertz-integrated circuits and antennas, which would serve as the starting point for developers in this field of work [6], [7]. I’m happy to report that, as part of my research in developing a terahertz transceiver, I have made the following accomplishments over the course of my fellowship:

- I was invited to write a magazine article about my research on silicon-based generation and detection of terahertz waves. The article, titled “Gone in a Picosecond: Techniques for the Generation and Detection of Picosecond Pulses and Their Applications,” was published in the November issue of IEEE Microwave magazine. The article focused on different techniques for the generation and detection of terahertz waves and their real-life applications [8].

- I developed a new pulse-based joint spacial coding approach for spatially secure communication, and a new mathematical linearization-based imaging approach to image partly occluded objects. This work was published in IEEE Microwave Transactions in a paper titled “Ultra-Wideband Joint Spatial Coding for Secure Communication and High-Resolution Imaging” [9]. In this project, not only were we able to show spatially secure communication with information beam-width as narrow as few degrees, we demonstrated pulse-based complex scene imaging. As shown in Fig. 1, multiple transmitters and receives are used to image a scene with different level of occlusions.

- I published a conference paper, which was the precursor to the above-mentioned journal, titled “Ultra-Wideband Pulse-based Directional Modulation” in IEEE MTT-S International Microwave and RF Conference. This paper was nominated for the best paper award [10].

- I currently have a conference paper and a journal paper, both of which highlight novel impulse-based sampling architecture for UWB ultra-high-speed ADCs, under review.

Finally, I plan to defend my Ph.D. at the end of this summer. My thesis investigates and reports on the building of next-generation terahertz transceivers and samplers with picosecond-sampling windows that are based on integrated circuit technology.

II. FUTURE WORK AND CAREER PLANS

My plan for the immediate future is to build a complete single-chip solution for the generation and detection of terahertz waves in order to utilize their latent potential to create real-world applications.

In the long term, I hope to become an entrepreneur by starting my own research company that is based largely on my Ph.D. work, as I believe that the next generation of sensing will be largely based on the terahertz wave. However, I haven’t surrendered the possibility of working in the industry for a couple of years prior to starting my own company in order to gain exposure and valuable experience.

III. IMPACT OF THE MIT-S FELLOWSHIP AND IMS

It has been a privilege and honor to have my research recognized by the IEEE Microwave Theory and Techniques Society (MT-T-S) and bestow with a fellowship. This recognition not only promulgated my work but also igniting endless discussions with like-minded professionals, thus serendipitously cultivating to new ideas. I have been attending IMS every year since 2012 and the quality of research showcased is second to none. It provides a great platform for novice apprentices to interact with the honorifics and foster collaboration in this closely knit society. I strongly recommend every young researcher to apply for this fellowship.
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REFERENCES


