THz Electronics: Transistors, TMICs, and High Power Amplifiers

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Abstract — This paper will discuss recent advances in the Terahertz (THz) Electronics program sponsored by the Defense Advanced Research Projects Agency (DARPA). DARPA has been working to develop THz technologies to effectively generate, detect, process, and radiate sub-millimeter wave (sub-MMW) signals between 0.3 to 3 THz in order to exploit this practically inaccessible frequency domain for imaging, radar, spectroscopy, and communications applications. In addition to the direct exploitation of THz radiation and circuitry, there are significant potential opportunities for very fast electronics to improve precision analog microwave circuits and high-resolution data converters at substantially lower overall operating frequencies. Revolutionary THz transmitter and receiver demonstrations are the ongoing focus of a portfolio of programs within DARPA’s Microsystems Technology Office (MTO). These programs—and previously completed efforts—are building the critical aspects of THz devices, integration technologies, and metrology necessary to realize applications. The Sub-millimeter Wave Imaging Focal-plane Technology (SWIFT), the Technology for Frequency Agile Digitally Synthesized Transmitters (TFAST), and the Terahertz Electronics (THz Electronics) programs pushed the frequency scaling limits of InP-based HEMTs and HBTs. Useful transistor response faster than 1 THz has been achieved and transistors of this class have enabled the world’s fastest THz monolithic integrated circuits (TMICs) with operation and useful gain above 0.67 THz. In order to realize compact THz high power amplifiers (HPAs), micromachined vacuum electronic devices are being developed in the High Frequency Integrated Vacuum Electronics (HiFIVE) program for 220 GHz and in the THz Electronics program to generate 0.67, 0.85, and 1.03 THz radiation sources. A demonstration of a 670 GHz HPA with 15 GHz of instantaneous bandwidth is expected by the time of the conference. The THz Electronics program is also developing low-loss THz interconnects and integration techniques to couple transmit and receive TMICs with the HPAs for enabling compact THz coherent heterodyne transceivers. The innovative heterogeneous integration processes being developed under THz Electronics will enable new classes of components for manipulating the sub-MMW spectrum for defense systems.