TERAHERTZ DETECTION AND IMAGING USING FIELD EFFECT TRANSISTORS OPERATING IN THE SATURATION REGIME

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ABSTRACT

Terahertz technologies are attracting a great deal of attention nowadays, with numerous applications ranging from medicine (skin and breast cancer diagnosis); to homeland security (explosive and concealed weapons detection and security screening in public places); radio astronomy (and free space communication). These applications can be dramatically expanded by developing terahertz electronic devices. Plasma wave terahertz electronics has been emerging in the last decade. THz electronics uses plasma waves in field effect transistors (FETs) for detection, emission, and (more recently) imaging of terahertz radiation. This technology offers several advantages, such as compact design, high integration capability, low cost, broadband operation, and very fast response for real time THz applications. However, its sensitivity was lagging the other commercial detectors in THz market.

This dissertation reports on much more efficient and novel approaches to plasma wave THz electronics. A completely unexplored regime of terahertz broadband detection using FETs operating in the deep saturation regime has been studied both theoretically and experimentally at room temperature. The first transistor array structures for THz detection has been designed, fabricated, and successfully tested. Our results reveal: a linear growth of THz responsivity in the deep saturation regime; an additional increase in responsivity of transistor arrays that is proportional to the number of series-connected transistors; a dramatic change in coupling of THz radiation to transistor channel when it was driven deeper in saturation regime. This coupling mechanism allows the more accurate imaging of THz waves at sub-wavelength resolution. This new feature was confirmed by imaging of 1.63 THz laser beam profile with few microns spatial resolution using single and multiple transistors. In addition, THz responsivity of FETs has also been improved by at least an order of magnitude with great possibility of further improvement in future. These results have boosted the performance of plasma wave detectors and have a promise for its rapid utilization in commercial THz systems.