**Broadband terahertz imaging with sensitive graphene field-effect-transistors**

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Interest in terahertz (THz) systems and technology has grown significantly over the past 10 years for their potential in non-invasive imaging, sensing and high-data-rate wireless communication. Waves at THz frequencies present an alternative to x-rays for imaging through paper, cloth, wood, concrete, plastic and many other materials. In contrast to x-rays they are non-ionizing and therefore inherently safe. Applications of THz radiations range from nondestructive testing to medical imaging, security screening of objects and persons [1].

Several groups have also considered using THz waves to transmit data in wireless communications. Wireless THz communications for which THz waves are the free-space carrier of data are recognized as the promising breakthrough solution to achieve data-rates up to 100 Gbps [2]. THz imaging and wireless communication applications suffer, however, from the lack of fast and low-cost detectors operating at room temperature and in this work we show that graphene based plasma nanotransistors can be a good alternative. .

Nanotransistors offer great prospect for the development of innovative THz detectors. The interest in using field-effect transistors for THz applications was initiated by the theoretical work of Dyakonov and Shur, who predicted that the nonlinear properties of the 2D plasma in the transistor channel can be used for detection of THz waves at frequencies significantly higher than the transistor cut-off frequency [3,4].

Graphene field-effect nanotransistors were recently demonstrated showing maturity of graphene microelectronics. In this paper, we present extensive studies on first THz detectors based on monolayer and bilayer graphene field effect transistors. The specific detection sign reversal related to the graphene Dirac point change of electron to hole conductivity is clearly demonstrated. We show that the detectors consisting of a gated 2D massless fermion gas as rectifying element and an integrated coupling antenna achieve a responsivity above 1.2 V/W (1.3 mA/W) in photovoltage and photocurrent mode respectively, and a noise equivalent power below 2 $10^{-9}$ W/Hz$^{0.5}$ We show also that these detectors can operating as sensitive room-temperature broadband THz detectors in THz imaging systems [5,6]. Feasibility of THz food industry quality control (Fig.1a-c) and agriculture watering control (Fig.1d) imagers using graphene nanotransitor sensors/detectors is demonstrated.

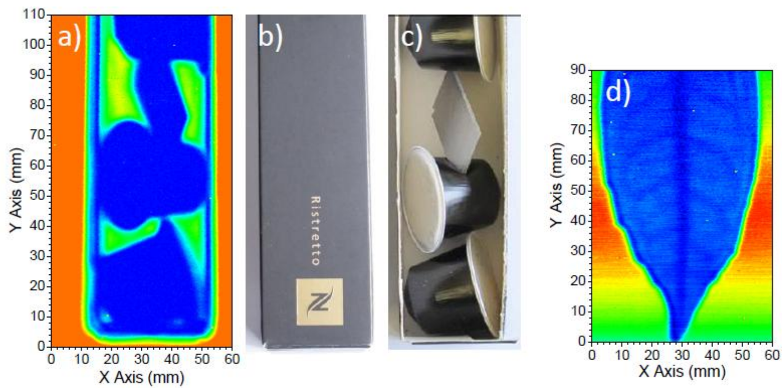


Fig. 1: Fast, large-area, THz imaging. a), Photograph and 0.3 THz transmission mode image of a closed coffee-capsule box with a metallic knife blade inside. b) For visible light illumination the contents cannot be seen, either by naked eye or by the CCD camera used to take the picture. b) Same box as in a), but with one side removed. This allows the inside of the box to be seen, but requires the destruction of the packaging. c) 0.3 THz transmission image of the sealed, intact box mounted on a XY stage, with spatial resolution 0:5 µm. Our graphene-based terahertz detector allows one to monitor the contents of the closed package. d) 0.3 THz image of a leaf revealing the veins.

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