Terahertz Imaging Using Strained-Si MODFETs as Sensors

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Development of new terahertz (THz) sensors is increasing in interest due to their potential for THz imaging and spectroscopy. One alternative to develop direct THz sensors is based in the oscillation of the plasma waves in the channel of sub-micron FETs. Non-resonant detection has been experimentally demonstrated already. It was first observed on GaAs and GaN FETs and later on Si FET [1, 2]. High responsivity (200 V/W) and low noise equivalent power (NEP) [3] were obtained with Si-MOSFETs with different gate lengths (120 and 300 nm). A 3x5 Si MOSFET focal-plane array processed using a 0.25µm CMOS technology were used [4] for imaging at 0.65 THz. Recently, THz imaging was performed using a n-MOS Si FET with an integrated bow-tie coupling antenna with both high responsivity and low NEP [5]. Strained-Si (s-Si) transistors are suitable for THz applications in reason of: (i) the channel mobility is higher (1350-1900 cm^2/V.s) than in conventional CMOS [6], (ii) high frequency and noise performances are closed to the III-V devices ones, (iii) the heterosystem Si/SiGe is fully compatible with mainstream CMOS.
The n-channel Si/SiGe MODFETs used in this study were grown by MBE on a thick relaxed SiGe virtual substrate grown by low-energy PECVD on plain Si wafers. The final Ge mole fraction in the virtual substrate was x=0.45. The device had a 9 nm tensile strained (in terms of biaxial deformation) Si channel sandwiched between two heavily doped SiGe electron supply layers to generate a high carrier density in the strained-Si quantum well. The top of the device layers was capped with a thin layer of Si, so as not to compromise the quality of the Schottky gate. The ohmic contacts were not self-aligned. The transistors used had gate lengths of 50nm, gate widths of 30µm and source-to-drain distance of 2µm.

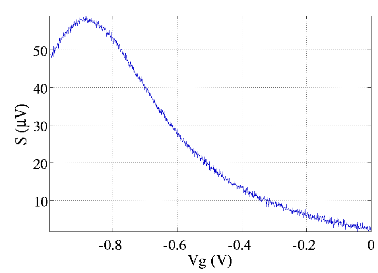

Fig. 1. Measured photoresponse of the device as a function of the gate voltage at 0.292THz.

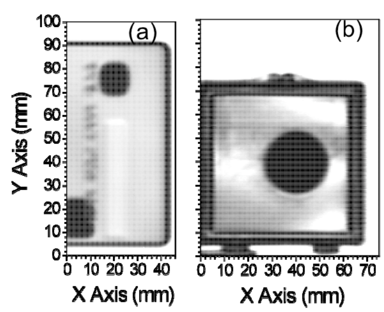

Fig. 2: Terahertz image of (a) Visa card (b) plastic box with a mirror inside at 0.292THz.

The device was subjected, at room temperature, to terahertz radiation and the signal was measured using the lock-in technique with a chopper at 1.29 KHz. Figure 1 shows the photoresponse signal that exhibit a maximum around the threshold voltage (V_{th} = -0.84V). This behavior has been reported earlier and explained as non-resonant detection due to low quality factor ($Q=\omega\tau<1$) and low coupling of the incoming light to the device [1, 6]. Then, the device was used as a single-pixel sensor in a THz imaging system; the source was a Gunn diode at 0.292 THz [5]. The gate was biased around V_{th}. Figure 2 shows the obtained THz image of a VISA card (2-(a)) and a plastic box with a hidden mirror inside (Fig. 2-(b)). These images clearly demonstrate the potential of such transistors for cost effective and compact THz imaging systems.

In the Conference we will report on: (i) non-resonant detection of THz radiation (0.292 THz) at room temperature of a 50nm gate length s-Si MODFET, (ii) THz imaging where the transistor was used as a THz sensor in a pixel-by-pixel system.

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