CMOS integrated system for Terahertz Detection

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***Abstract*— We present the study of a new structure for integrated rectifier, realized with standard CMOS technology, suitable to detect the terahertz radiation, at room temperature. The structure consists of a capacitive rectenna, designed as a patch antenna realized with the last metal layer of the CMOS process. A whisker reaches the gate of a MOS-FET transistor from the antenna, obtained with a standard via. Rectification can be obtained by the self-mixing effect occurring into the plasma waves generate underneath the gate. The proposed solution can be integrated with existing imaging systems, since it does not requires scaling toward very narrow and costly technological node.**

I. INTRODUCTION

IMAGING and spectroscopy applications in the THz spectrum range have a great potential in time-domain spectroscopy communications, biomedical imaging, and security control [1]. In past decades a great effort from the research community has been dedicated to this region of the electromagnetic spectrum, pushing the known microwave and optical THz devices through a constant progress, focusing in particular on the development of detectors in terms of noise equivalent power and on the use of commercial technologies.

In this optic, integration of arrays in standard CMOS technology is mandatory to make exploitable readout and elaboration electronics capabilities. This paper presents the direct integration of the antenna with a rectifying device obtained by modification of commercial CMOS Image Sensors (CMOS ISs).

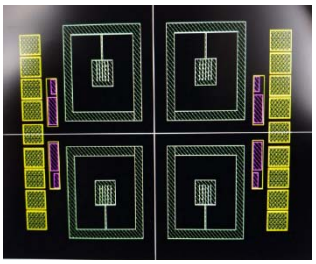

Fig. 1. Layout of the new patch-slab antenna directly integrated on the surface of the CMOS chip.

I. ANTENNA GEOMETRY AND DETECTOR

A planar antenna, realized directly shaping the metal layers available in the CMOS technology, has been recently proposed [2]. A patch slab antenna is fabricated using a standard CMOS technology from ST Microelectronics. The layout of the chip is presented in Fig. 1. The final metal layer contains for each chip four antenna structure constituted by a square patch antenna with dimension 80 µm, surrounded at a distance of 80 µm by a metal ring. The first layer of metallization of the CMOS process is used to realize a ground plane. The metal ground plane is connected by ohmic contact with the p type semiconductor substrate. The metal ring is connected to ground by a number of diodes structure which on one side allows the electrostatic protection, on the other side ensure shunt at high frequency and finally permits to keep the structure floating at DC and thus apply a polarization to the detector connected to the antenna. A metal line connects the metal ring of the four structures with pads aligned within the pads columns at right and left. A CST simulation of the patch–slab antenna structure is shown in Fig.2.

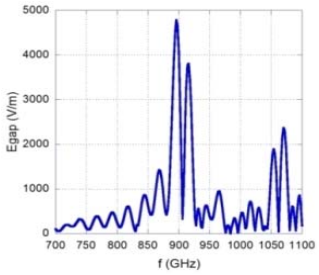

Fig. 2. Electromagnetic simulations showing the high Field Enhancement which can be achieved by the planar antenna.

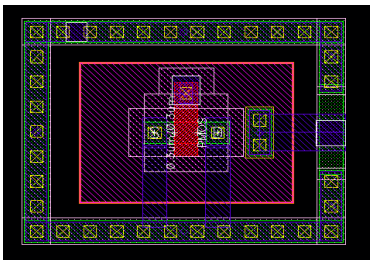

Fig. 3. Schematic of the layout of the CMOS detector.

II. CONCLUSIONS

In this paper we presented a new THz detection system integrated in a CMOS chip. We studied the new structure and the coupling with the semiconductor detector. In particular, we demonstrate that the depletion region of a MOS-FET transistor, with a metallic whisker connecting the gate of the transistor to the antenna pad, provides an efficient rectification effect.

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