Intitulé

Silicon-based THz power sources in nm (Bi)CMOS processes

Introduction

Silicon-based imagers in the visible and near-infrared spectral bands have already generated enormous business opportunities worldwide, with continuing growth in markets such as cell phones, automotive safety, authentication, and security systems. Imaging sensor revenues of more than $4B were expected in 2009 at the component level alone. Similarly, applications in the terahertz spectral band would profit massively from the capabilities of silicon process technologies making possible affordable and reliable imagers, notably in the industrial safety and security areas, biomedical, agriculture and wellness. In particular the high integration capability of silicon process technologies renders them an enabler for entirely new imaging concepts that are not feasible in any other terahertz technology.

State of the art context:
The most recent research work at the Bergische Universität Wuppertal in collaboration with STMicroelectronics and IEMN/ISEN Lille has led to the development of the world-first large-count 1 k-pixel camera in a bulk 65 nm CMOS process with a full video rate capability and a completely integrated read-out circuitry [Sherry 12. The 32 x 32 FPA exhibits a pixel pitch as small as 80 μm, defined by a novel on-chip ring antenna, and is designed to accommodate silicon lens optics for a wide operation bandwidth of 0.6-1 THz. The camera operates at 25 fps consuming 2.5 μW/pixel, fully integrated in 65nm CMOS with no specific options.

See also: http://spectrum.ieee.org/semiconductors/optoelectronics/a-cheap-terahertz-camera

Descriptif

The work targeted for this PhD candidate aims to continuing the work done since 3 years in collaboration with Bergische Universität Wuppertal, now taking in charge the feasibility of Silicon integrated power sources in the frequency range of 300 to 1000 GHz . The target processes are 65nm CMOS, 55nm BiCMOS and 28nm FDSOI CMOS. The student will work inside an interdisciplinary team of microelectronic designers, antenna designers, THz imaging experts, THz metrology experts.

PhD Study Subject Description

Within the frame of this thesis, we aim to achieve a breakthrough in (Bi)CMOS integrated power sources in the THz frequency range by applying new design ideas. Recent state of the art [Tousi 12], [Zhao 12] has proven the power sources feasibility in 65nm CMOS at about 300GHz, with an output power of about 0 dBm and a tuning range around 4.5%.
The target of this work is to prove feasibility of THz power sources and with industrial design margin, with output frequencies in the range of 300 to 600GHz, and an equivalent radiated output power around 15dBm. The PhD student will have to master the following skills:
- RF and mmW design, and especially oscillators theory
- mmW EM modeling for passive devices; Silicon integrated antenna design
- good semiconductor physics knowledge for active devices

This thesis defines itself as pioneer work regarding two different aspects: future applications and market fields for ST and utmost limits of advanced (Bi)CMOS technologies.

PhD Study Planning

1. Bibliography study on the targeted applications and imaging techniques at mmWave and THz range (integrated or discrete approach) => 1 months
2. Oscillator theory study, Active device modeling and passive structures study => 2 months
3. First THz power source design and implementation => 9 months
4. Second implementation: circuit design and measurement techniques => 9 months
5. System implementation chip: implementation and measurements => 12 months
6. PhD Defense writing => 3 months

PhD Thesis Organisation and Functioning

This CIFRE PhD thesis will be supervised as follows:
- University supervising:
  - Professor Ulrich Pfeiffer from University of Wuppertal, Germany; 50% timing
  - Professor (Directeur de Recherche CNRS) Andreas Kaiser from ISEN/IEMN; 20% timing
- Industrial supervising:
  - Andreia Cathelin from STMicroelectronics, TR&D / CCDS / PIMDS; 30% timing

This thesis will benefit from the international scientific reputation of both university laboratories and specially the professors to carry out this difficult PhD subject. IHCT laboratory from University of Wuppertal, under the name of Professor Pfeiffer, has uncontested international scientific leadership concerning integrated CMOS imagers for mmWave/THz detection. ISEN/IEMN, under the name of professor Kaiser, is well known among the international scientific community for his work in the field of analog circuits.

Part of this thesis is considered in the frame of ST/IEMN Common Lab, and in the "mmWave thematic platform".

The PhD thesis should start by October 2014 and finish by October 2017. The chosen candidate may be registered as PhD student either at Wuppertal, Germany, or at Lille Universities, France (depending on his/her nationality).

The timing repartition is the following:
- from Oct 2014 to Dec 2016, the PhD student will be based at Wuppertal University and ISEN/IEMN Lille;
- from Jan 2017 till the end of the thesis, the PhD student will be based at STMicroelectronics Crolles.

When needed, the PhD student may spend a period of time on the other working places, for specific activities (measurements, design with specific CAD tools, …)

Reporting: Every 6 months, the PhD student has to provide a detailed scientific report to all the parties on the work done so far. Every 2 months, work advancement meetings will be organized to insure the follow-up and a good co-operation between the different parties.

The work generated from this PhD study will give place to internal presentations inside the two university labs and the company, and also to international conferences and symposia presentations. International journal paper writing, as well as patent filing, are strongly encouraged.

References:

Cathelin, and U. Pfeiffer, “A broadband 0.6 to 1 THz CMOS imaging detector with an integrated lens,” IMS, Baltimore, MD, 6 2011.


### Niveau d’étude requis

Ingénieur en Microélectronique ; Master of Science

### Compétences requises

- analog and RF, mmW design
- EM simulations
- semiconductor physics
- oscillators

### Dates et lieu de la thèse

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- Andreia CATHELIN andreia.cathelin@st.com
- JR n°