PROJECT PROFILE

2T206: Silicon analogue to millimetre-wave technologies (SIAM)

TECHNOLOGY PLATFORM FOR PROCESS OPTIONS

Partners:

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CEA-LETI
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Key project dates:

Start: January 2008
End: December 2010

Countries involved:

France
The Netherlands
Sweden

New silicon-based technology platforms are needed for emerging very high frequency and millimetre-wave consumer applications such as 77 GHz automotive radars, 60 GHz wireless local area and personal area networking (WLAN-WPAN) and 100 Gbit/s optical data communications. The 2T206 SIAM project is investigating and comparing 130 nm SiGeC bipolar CMOS (BiCMOS) and 65 nm silicon-on-insulator (SOI) CMOS on a high resistivity substrate for the realisation of critical electronic components for these applications. The objective is to establish a leadership position for European chipmakers in these key domains, so strengthening the overall competitive role of Europe in the global microelectronics market.

Europe is keen to establish the technological foundations to build the infrastructure for emerging very high frequency cabled and wireless applications to provide European citizens with a powerful network of reliable and widely accessible broadband communications links and to improve safety and security.

However, the future development and growth of wireless and cabled optical communications depends on the timely availability of high-performance components. The realisation of these circuits depends on the availability of advanced microelectronic technologies and on pre-emptive collaboration between design teams and chip manufacturers.

The MEDEA+ 2T206 SIAM project set out to address the open questions and unsolved problems relating to the economic realisation of the building blocks for these key circuits. SIAM is investigating two advanced technologies – 130 nm silicon germanium carbon (SiGeC) BiCMOS and 65 nm SOI CMOS on a high resistivity (HR) substrate – to enable mass production of electronic circuits for very high frequency devices in Europe.

Seizing the opportunities

The millimetre-wave market is currently based on so-called III-V semiconductor technologies and so limited by high manufacturing costs, high power consumption and the limited integration scale of those technologies. However silicon is now considered as the semiconductor material of choice to address such applications. This has been made possible by the dramatic increase in the frequency performance of active silicon devices. Cut-off frequencies extending beyond 200 GHz are now reached by both SiGeC bipolar transistors and nanoscale CMOS devices. Special back-end options will also exhibit large improvements for passive and antenna on-chip integration.

All of the main critical circuit building blocks in 77 GHz radar transceiver applications have been demonstrated at research level using 230/280 GHz fT/fmax SiGe bipolar technology. However, full systems integration requires dedicated millimetre-wave SiGeC BiCMOS technology, which has not been available in Europe.

Promising performance has also been reported for 60 GHz signal-processing circuit blocks fabricated using 90 nm CMOS technology. Faster devices available in a 65 nm process should extend the capability of pure

CMOS for the realisation of millimetre-wave products in SIAM circuit blocks.

In high-speed optical communications applications, research circuits for more than 100 Gbit/s transmission systems have already been realised with 220/250 GHz fT/fmax SiGeC bipolar technology. Those projects successfully demonstrated the technical feasibility of silicon-based, ultra-high-frequency electronics and revealed the requirements of future research activities. Commercial systems will be based on high-performance system-on-chip (SoC) solutions that combine analogue and digital functions. No supplier in Europe currently offers the required high-speed SiGeC BiCMOS technology.

Based on CMOS

On the basis of power consumption and integration requirements, high-speed signal processing systems of higher complexity must be based on CMOS technologies. The first promising research results demonstrated the feasibility of 90 nm CMOS-based signal processing with analogue-to-digital and digital-to-analogue conversion up to 40 Gbit/s. The much higher performance potential of 65 nm SOI CMOS technologies should allow the realisation of competitive chips for 100 Gbit/s applications.

All radio-frequency (RF) front-end components for 60 GHz WPAN-WLAN applications are today implemented in gallium arsenide (GaAs) and indium phosphide (InP) technologies. However silicon technologies offer a cheaper alternative.

SOI CMOS has been identified as one possible method of increasing the performance of CMOS over that offered by simple scaling – CMOS SOI offers a 20 to 30% performance gain over bulk CMOS. The 65 nm CMOS SOI process proposed in SIAM offers an opportunity for the use of very-high resistivity substrates to achieve low-loss passive elements and on-chip antenna integration. These capabilities, together with SOI n-type field-effect transistors (n-FETs), open up exciting opportunities for low-power RF and millimetre-wave circuits.

Weighing up the options

Two types of silicon technology platform will be investigated:

1 A **millimetre-wave oriented 130 nm SiGe BiCMOS technology**, featuring a 230/280 GHz fT/fmax SiGeC heterojunction bipolar transistor (HBT), dual threshold voltage and dual gate oxide 130 nm CMOS devices and dedicated six-layer copper metallisation including two 3 μm thick layers. Such metallisation is mandatory to support transmission lines at 77 GHz; and

2. A **65 nm low-power CMOS-SOI process**, using 300 mm HR SOI substrates to allow for millimetre-wave designs with high quality passive devices such as inductors or transmission lines without relying on dedicated thick-film metallisation and that also allow for on-chip antenna integration.

The performance of these technologies will be evaluated and compared through the realisation of several critical circuit building blocks and state-of-the-art demonstrators:

- SiGeC BiCMOS circuits for greater than 100 Gbit/s Ethernet (100GBE) and 77 GHz automotive radar sensors;
- CMOS-SOI transceiver and signal processing building blocks for 60 GHz WPAN and WLAN applications, as well as key signal processing building blocks for 100GBE and 100 Gbit/s backplanes; and
- Transmitter/receiver circuits operating at microwave frequencies for sub-carrier multiplexed (SCM) optical communication systems and analogue/digital circuits capable of sampling rates up to 20 giga samples/s.

The supply of silicon technology platforms able to handle greater than 100 Gbit/s optical communications to serve the requirements of ultra high speed communications will give momentum to European chipmakers and the telecommunications industry. These platforms are essential for the evolution of future high speed communication products.

Boosting road safety

Development of 60/77 GHz radar sensors for automotive applications will boost road safety by enabling development of new driving aids such as millimetre-wave radar. Other applications include passive millimetre-wave imaging technologies for improved airport security, and intelligent building controls to reduce energy consumption, while providing enhanced user comfort. Demonstrators are targeted to automotive applications with very stringent quality requirements so that these technology platforms can serve as industry standards for such products.

Finally, work on 60 GHz wireless networking will contribute to the millimetre-wave based alternative physical layer for the existing 802.15.3 WPAN standard 802.15.3-2003. Standard completion was reached in May 2008, with approval expected in September 2009. The new standard will be 802.15.3c.

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