PROJECT RESULT

Technology platform
for process options

MEDEA+

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

New silicon CMOS technologies for millimetre-wave applications

So-called 'millimetre-wave' semiconductor technologies form the basis of critical consumer applications such as automotive radar systems, wireless networking and optical data communications. However the established technologies in these areas tend to be high-cost and limited in their integration capabilities. The MEDEA+ SIAM project developed two new silicon-based technologies, 130 nm SiGeC BiCMOS and 65 nm CMOS-SOI, which offer the potential for substantial cost savings in the production of the electronic components for these applications, and could well expand this whole market sector.

High-frequency semiconductor technologies form the basis of a number of key consumer applications, for example automotive radar, wireless local area networks (WLANs) and optical data communications. Yet with high production costs and limited integration, they remain a niche area of the semiconductor market.

However recent advances based on silicon technology – rather than gallium arsenide – have underpinned a dramatic increase in performance at high frequencies; active silicon is now considered the technology of choice for such applications. The MEDEA+ SIAM 2T206 project investigated the potential of two advanced silicon technologies in this area.

SIAM aimed to lay the foundations for critical electronic circuitry in these applications, foundations which could eventually underpin mass production of such devices in Europe. The ultimate goal was to establish a leadership position for European chipmakers in these key domains.

Two new silicon technologies

The MEDEA+ project investigated and compared two key areas of silicon technology, 130 nm silicon-germanium-carbon (SiGeC) bipolar plus CMOS (BiCMOS) and 65 nm silicon-on-insulator (SOI) CMOS on high resistivity substrates. These can provide platforms for emerging high frequency and millimetre-wave consumer applications such as 77 GHz automotive radars, 60 GHz wireless networking for WLAN and wireless personal networks (WPANs), and 100 Gbit/s optical data communications.

SIAM realised a key objective with qualification of the BiCMOS technology for production. The BiCMOS9MW platform was demonstrated as feasible for high-frequency applications at 60 GHz, with key building blocks which addressed the range from 60 to 94 GHz. The new SiGeC BiCMOS circuits are capable of performance in excess of 100 Gbit/s for Ethernet applications and 77 GHz for automotive radar sensors.

Project-partner Philips produced a three-channel 60 GHz beam-forming transmitter with programmable true-time delay matrix, a 60 GHz voltage-controlled oscillator (VCO) and a 60 GHz phase-locked loop, all using the BiCMOS9MW platform.

Another partner, Catena, developed a beam-forming radio frequency (RF) front-end at the 60 GHz level, which included the low-noise amplifier, VCO, mixer and quadrature divider. Once issues with the first design were resolved, performance was in line with expectations.

Development of the CMOS65 SOI process was also successful. It can support transceiver and signal-processing building blocks for 60 GHz WPAN and WLAN applications, as well as for a

number of Ethernet functions. The final stages of the project saw extensive device characterisation and modelling to support further development and optimisation of the technology.

SoC approaches to HF design

The existing millimetre-wave market was beset by high manufacturing costs, high power consumption and limited integration capabilities. SIAM has now made available two new silicon-technology platforms that can compete with these established technologies, as well as support new system-on-chip (SoC) approaches to circuit design. These two new platforms, the millimetre-wave oriented 130 nm SiGe BiCMOS technology and the 65 nm low-power CMOS-SOI process, are now available in Europe for production and industrialisation.

BiCMOS9MW is only the second 0.13 μm SiGe BiCMOS technology available worldwide for millimetre-wave applications – after IBM's 8HP process; BiCMOS9MW improves on the latter technology in several critical device parameters, such as the minimum noise figure of the SiGe heterojunction bipolar transistor and the attenuation constant in transmission lines. It is now a production-ready platform which has been taken up and further optimised as part of the partners' commercial operations.

The BiCMOS9MW technology has been used by project partners STMicroelectronics, IMS, Philips, Catena and TU Delft to design RF circuits representative of key consumer applications with a special focus on the automotive radar from the Dutch partners – Philips, Catena and TU Delft.

The 65 nm CMOS SOI technology has been used by project partners STMicroelectronics, LETI, IMS, IEMN, TU Delft, Ericsson, SP Devices and Acreo to design RF circuits addressing some targeted applications. Swedish partners Ericsson, SP Devices and Acreo focused on RF circuits suitable for a 100 Gbit/s sub-carrier multiplexed (SCM) optical transceiver front end. The component specifications derived from system simulations were challenging, however, measurements from the circuitry produced indicated that the 65 nm CMOS SOI technology offers performance to spare.

In addition, the two technologies can underpin new types of transmitter/receiver circuits operating at microwave frequencies for SCM optical communication systems and analogue/digital circuits capable of sampling rates up to 20 Giga samples/s.

New market opportunities

The two technologies developed in SIAM provide European chip-makers with a means of expanding important consumer-electronics markets. BiCMOS for example offers a low-cost route to applications such as automotive radar. The potential production cost savings make it possible to envisage collision-avoidance radar fitted to every car, even low-end models.

They also open up new opportunities in the domestic communications market, with high-bandwidth optical and wireless connections possible in the home between, for example, a smart phone and a set-top box. Existing approaches using Bluetooth are limited in bandwidth. With the technologies developed in SIAM, video streaming and other high-bandwidth applications using such devices become entirely practical.

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MEDEA+ focuses on enabling technologies for the Information Society and aims to make Europe a leader in system innovation on silicon.