PROJECT RESULT

IC technology integration

T204: Advanced SiGe bipolar and BiCMOS technologies for wireless applications (ASGBT)

High performance achieved in on-chip microwave components

Radio frequency (RF) devices are found in many key applications – from wireless local area networks to mobile phones. As new chips become available, so corresponding markets evolve. The MEDEA+ T204 ASGBT project has developed methods for modelling, designing, simulating and producing a range of on-chip RF components, both active and passive, for use in devices operating at microwave frequencies. Building blocks operating up to 25 GHz were fabricated and tested. The resulting technologies ensure high bandwidth with low noise levels and very low power consumption at globally competitive cost levels.

MEDEA+ T204 ASGBT supported the effort towards ensuring a leading position for the European microelectronics industry in wireless manufacturing processes and systems applications. While CMOS has become the main process used in the semiconductor industry over the past decade, advanced silicon-germanium (SiGe) bipolar and BiCMOS technologies are increasing in prominence for combined RF/analogue and digital broadband systems. This trend is likely to accelerate with the move to complete system-on-chip (SoC) solutions.

The overall goal of the project was to develop SiGe bipolar and BiCMOS technologies for wireless applications in the 2 to 25 GHz frequency range. Uses include wireless local area networks (WLAN) using 2.4 GHz Bluetooth and 5.5 GHz HiperLAN2 standards, and high-speed digital links between mobile phone base stations. Work involved setting new standards for fabricating RF devices, as well as increasing the accuracy with which they can be modelled and simulated.

Consortium partners – including chipmakers AMI Semiconductor, Infineon and STMicroelectronics – focused on developing advanced SiGe or SiGeC heterojunction bipolar transistor (HBT) and BiCMOS technologies comparable to the best in the world. These used 0.35μm and 0.25μm technologies with cut-off frequencies in the range of 50 to 70 GHz.

The project achieved key improvements by applying deep trench instead of junction isolation. Silicon-on-insulator (SOI) wafers were also used instead of standard silicon wafers; although these are more expensive, there are performance advantages as they offer improved RF isolation as well as better isolation between digital and analogue building blocks.

Simulation and modelling

Development in this frequency range requires extensive modelling and simulation. The project worked on the optimisation of RF bipolar transistor performance, and a statistical analysis of small-signal HBT model parameters. Models were devised and validated for noise and for nonlinear active devices, as well as for varactors, inductors, capacitors and interconnections. These show improved accuracy at high frequencies.

The influence of noise generated by the chip substrate on low-noise amplifiers (LNA) was also studied. Modelling software enabled the effect of internal signal coupling through the substrate to be assessed, as well as the influence of external noise sources. It was observed that when noise from a typical circuit, in this case a WLAN device, was injected into the amplifier at various points, the level of noise coupled into the LNA itself was acceptably low.

Interconnection structures were investigated with full-wave 3D simulations to ascertain their true behaviour at elevated frequencies, and a calculation scheme was developed to characterise 3D structures such as corners, bends, widenings and simple spirals. This made it possible to assess the feasibility of employing interconnection lines and the earth plane as microwave transmission lines from which various components – such as transmission line stubs – could be created. Successful tests were carried out at 50 GHz, and there was good agreement between the measurements and the simulated model.

Advanced RF transceivers blocks and demonstrators were designed, manufactured and characterised to validate the SiGe technologies developed – these covered both active and passive elements. Demonstrators included an LNA and down-converter for a HiperLAN receiver, and a fully integrated LNA and IQ down-conversion mixer for wideband code division multiple access (W-CDMA) applications.

Excellent collaboration

Such a specialised project could only succeed with excellent teamwork within the consortium. Horizontal collaboration took place between the chipmaking partners, where work on process modules and module development was undertaken. Vertical collaboration took place within the overall value chain, with research and systems house partners sharing their expertise on new technologies and design work. This co-operation was especially valuable because partners were able to preview the developments and make plans for their adoption before they were ready for general release.

By the end of the two-year project, two new generations of process technology were fully developed: BiCMOS SiGe at 0.35 and 0.25μm. The design process is very effective for RF products and is suited to low power and low noise applications. The new model will also lead to faster design cycles and less re-engineering. Overall integration was improved with more high quality passive components on chip, reducing power needs and cost.

In the meantime, the 0.35μm process is already in production, and the 0.25μm process is about to be launched. In addition, some process steps were developed for individual SiGe transistors at 0.18μm, although further work is needed before this can be used on a commercial scale.

Opening up new markets

These processes will open up access to new and interesting markets. Although demand for mobile phone base stations is slow at the moment, this will pick up as third generation networks start to come on stream. Growth is expected in the market for wireless data links, wireless LANs, and links between buildings and between mobile phone base stations.

As a result of this project, Europe's position as the major global supplier of cost-effective RF chips and systems for wireless communications and third generation mobile phone applications will be reinforced. And the project is paving the way for the development of 12 GHz satellite communication networks as well as 20 GHz automotive collision-avoidance radar systems.

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Partners

AMI Semiconductor
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Chalmers University of Technology (CTH)
Ericsson AB
IMEC
Infineon Technologies
Royal Institute of Technology (KTH)
STMicroelectronics

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Key project dates

Start: January 2001
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Countries involved

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France
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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.