PROJECT RESULT

Enabling technologies for heterogeneous systems

MEDEA+

2T401: High-frequency microsystems on silicon (HI-MISSION)

Multi-chip modules offer enhanced functionality for microwave systems and components

Radio-frequency microsystems for radar and microwave communications have multiple uses in the telecommunications, automotive and defence sectors. However circuit design and development at such frequencies pose immense challenges. The HI-MISSION project developed an innovative design platform based on multi-chip modules to give greater flexibility in microwave systems, reducing costs and decreasing development time for new products. The enhanced functionality will strengthen Europe's ability to supply highly integrated, low cost millimetre-wave front ends in key and high-value global markets.

Radio frequency (RF) and microwave systems play a vital part in applications in telecommunications, defence radar and automotive collision-avoidance systems. Yet manufacturers of such systems and components face particular production issues. As a result, the fabrication of high-frequency circuitry for specific applications has often been at substantial cost.

The MEDEA+ 2T401 HI-MISSION project set out to develop advanced, low-cost multi-chip modules (MCMs) and to evaluate their assembly in microwave subsystems. Use of MCM technologies offers several advantages over packaged groups of separate components. These include improved performance, greater miniaturisation and faster time to market.

HI-MISSION aimed to help European microelectronics manufacturers overcome some of the production challenges involved, and thus ensure Europe safeguards its position in advanced high-frequency communications and sensor systems.

Integrating passive components

A key innovation was development of a multi-chip-module production technique based on silicon substrates with enhanced functionality. This use of MCM technology enables the integration on chip-carrier substrates of not only standard chips using silicon (Si), silicon germanium (SiGe) and gallium arsenide (GaAs), but also of high-performance passive components such as high-density capacitors and tuneable components based on high-dielectric ferroelectric materials.

Such passive components cannot normally be directly integrated within the chip, as attempts often bring out issues such as processing/fabrication incompatibility, size constraints and differing temperature gradients. The key achievement of HI-MISSION was to develop a functional and tightly integrated platform for microwave applications that includes both passive and tuneable components within a single package.

Low-cost processes

Integration was carried out using low-cost, high-volume manufacturing processes optimised for microwave and millimetre-wave performance. Three application demonstrators were developed to prove the results: a telecommunications demonstrator, a military radar demonstrator and an automotive radar demonstrator. Circuitry was developed in CMOS, SiGe and GaAs semiconductor technologies for the three demonstrators.

HI-MISSION production techniques brought an added flexibility in that frequency-determining components – such as voltage-controlled oscillator resonators or low-noise amplifier match-

ing networks – could be integrated into the module rather than in the chip itself, thus spreading chip-integration costs over larger production volumes. This is particularly important for low-to-medium volume production applications – typical for microwave applications – where the lithographic mask cost in advanced integrated circuit (IC) processes can otherwise be prohibitive.

The project optimised module passives and interconnects for microwave performance up to 80 GHz, using both flip-chip – production mounting of chips by flipping them onto their backs – and 'hot via' methods, where chips are mounted using gold-stud bumps on the carrier substrate, but in an upright position rather than flipped. A pipeline analogue-to-digital converter (ADC) with fully user-transparent digital background calibration was also developed. This was the first single-chip solution to the interleaving of high-resolution – greater than 12 bit – time-interleaved ADCs.

Results being deployed

Partner Ericsson is now examining how to use devices developed within the project in a number of telecommunications systems and subsystems. The improved flexibility is expected to lead to significant cost reductions and a faster time-to-market in the long term.

For automotive radar, the project developments in MCM deposition (MCM-D) substrate technology, chips, circuits, interconnection technology, high-density packaging and integrated aerials show that the HI-MISSION platform has the potential to deliver lower cost millimetre-wave solutions for higher production volumes.

The two major chipmaking partners also benefited. Development and implementation of pipeline ADC architecture has boosted Infineon's technological edge. A high-performance ADC is a key building block in all chipsets, and often defines the performance of the whole system. And STMicroelectronics developed know-how on barium strontium titanate (BST) substrate materials and processing.

The project also gave significant input on applications requirements for tuneable devices that will find applications in telecommunications and high-end multimode mobile phones.

Specialist semiconductor manufacturer UMS has already proposed the developments within HI-MISSION to customers in the automotive sector, and has had very good feedback from its telecommunications, defence and avionics clients. The first application-specific ICs (ASICs) developed using the project results were already supplied to major customers in 2009.

The project has also established strategic contacts between European companies and research organisations.

Boosting European capabilities

HI-MISSION project results have contributed greatly to Europe's position in the manufacture of high-value RF/microwave components and systems, with all the implications this brings for business and employment.

Consumer markets are driven by cost, and up to 50% of the cost of microwave systems such as those used for automotive radar systems is in assembly. The microelectronics concepts developed within this MEDEA+ project will help simplify the assembly process, and thus help the market for automotive-radar sensors to take off.

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Saab
Signal Processing Devices
STMicroelectronics
UMS

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