PROJECT RESULT

Enabling
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MEDEA+

T126: Building-up embedded memories (BLUEBERRIES)

Major advances ensure leading technical position for Europe

System-on-chip (SoC) devices play a key and growing role from safety-critical car control units to mobile communications and smart cards. Developments in the BLUEBERRIES project led to major advances in static, dynamic and magnetic RAM for embedded memory in SoC devices, reducing the cost of such memories through increased density and yield, while maintaining high levels of memory robustness despite increasing miniaturisation. The results of this project have ensured European chipmakers have the industrial technologies required to remain in the vanguard of the global semiconductor market.

Embedded memory is used increasingly with the growing trend to fabricate complete system-on-chip devices. It offers higher speeds, lower power consumption and decreased costs compared with separate memories – and can provide greater system flexibility with ease of updating of system functions. Currently, embedded memory can account for 80% of an SoC; a baseband SoC for third generation (3G) mobile communications may include around 100 embedded memories of different types.

MEDEA+ has played a key role in the development of embedded memory technology. Its use is set to grow significantly in chip-equipped smart cards, safety-critical automotive electronics, consumer equipment and mobile communications. Moreover, Europe has established world-beating positions in smart card and automotive electronics markets.

Complementary actions

The MEDEA+ T126 BLUEBERRIES project set out to complement action on non-volatile memories being carried out in the MEDEA+ NEMESYS project. It addresses CMOS-based embedded static memory (SRAM) found in all types of application, dynamic memory (DRAM) used mainly in consumer electronics and magnetic memory (MRAM) – seen initially as a new universal solution. Principal objectives were to improve density, sizing, consumption, robustness and manufacturability of these three types of memory over a three-year period, equivalent to one generation of CMOS technology.

Requirements included advanced physical processes, design and validation methodologies, and computer-aided design (CAD) flows for design and production. The need for BLUEBERRIES was driven by the maturity of 90 nm technology, the emergence of 65 nm technology and the specification of application requirements meeting new market demands.

At the heart of the consortium were three global chipmaking players – Freescale, NXP and STMicroelectronics. They had decided to co-ordinate their R&D actions at a European level on the specific theme of embedded memories and maximise benefit from complementary industrial expertise distributed throughout their organisations. Very strong horizontal co-operation between the three was facilitated by the existence of common teams in the framework of the then Crolles 2 Alliance in France, which acted as the main industrial technology centre for this project.

BLUEBERRIES built on the results of previous work, which included the EU Information Society Technology nanoMEM project and the French MEMIS project. Innovation came from the participation of a series of research laboratories and institutes, complemented by two

CAD equipment suppliers that wanted to evolve their products to meet new industry requirements.

Following core processes

Specific extensions to the core CMOS process – first in 90 nm and later in 65 nm technology – had to be addressed. The intention was to develop the maximum of memories fully compatible with CMOS, based on technologies available in Crolles.

Each of the three different families of memories had its own specific targets:

1. SRAM: the basic memory family was qualified as soon as a new generation of CMOS technology was available. Targets were to improve performance in terms of power consumption, speed and robustness;
2. DRAM: structure and materials had to be chosen to fit 90 and 65 nm requirements. DRAM function relies on a specific capacitor; as dimensions reduce, this capacitor loses its properties compared with earlier generations, so new approaches, equipment and recipes were required; and
3. MRAM: a totally new technology where everything was needed for industrialisation. Development work in fact stopped in 2005 with no industrialisation at Crolles. However, Freescale proposed its first MRAM project in June 2006, based partly on the work in Crolles.

Facing up to main challenges

The main technical challenges were: reducing memory size; at least conserving if not improving performance in terms of speed and power consumption; and developing design methodologies to ensure correct implementation of memory in silicon even before the layout – this involved validating the memory concept before developing it in the wafer fab.

In terms of innovation, the most notable achievement is new methodology in the shape of 'formal techniques'. This involves developing rules and equations to verify the design by transforming geometrical development of the layout into mathematical rules. Such an approach is important because it was not possible previously to develop 10 MB or more of memory cells in silicon in less than a month. With formal techniques, it is now possible to do this in only a few hours, cutting time to market for the end product.

MRAM was seen initially as the future universal memory technology, but this is no longer true. Now the main potential competitor is probably the phase-change memory (PCM) – a new project today would probably work on PCM. So overall, MRAM was developed but not industrialised, leaving classical and standard memories to continue with success.

Meeting global needs

This MEDEA+ project was based around the Crolles 2 roadmap and the need to be competitive with IBM and Samsung for example. This was achieved successfully in terms of SRAM density and DRAM performance.

Technically, BLUEBERRIES has been a great success; memory-cell performance for 65 nm CMOS technology is now world class. So both STMicroelectronics and NXP are immediately able to work on a very challenging platform for the mobile phone and TV markets. NXP is particularly interested in embedded memory with low power, while Freescale and STMicroelectronics put more emphasis on speed rather than consumption.

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LSV (ENS-Cachan)
NXP (Philips Semiconductors)
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