PROJECT PROFILE

T124: High operating temperature systems on chip, assembly and reliability (HOTCAR)

ENABLING IC TECHNOLOGIES FOR APPLICATIONS

Partners:

AT&S
Atmel
C-MAC
Conti Temic
CRF
DaimlerChrysler
EPS
HARTING
IMOMEC
Infineon
Isola
Schlumberger
SERMA
Siemens
Siemens VDO
STMicroelectronics
Valeo

Project Leader:

Günter Lugert,
Siemens VDO Automotive

Key project dates:

Start: December 2001
End: November 2004

Countries involved:

Austria
Belgium
France
Germany
Italy

Increasing demand for electronics sustaining severe environmental conditions as found in car applications or oil drilling requires semiconductor chip operation at high ambient temperatures, well above those encountered in the majority of applications. In the future, engine and transmission units will be built and tested as complete assemblies, with all electronic control devices in place. That can only be achieved if the components are mounted directly on the unit where they will be subjected to long-term extremes of temperature, vibration and humidity. The primary technical goal of MEDEA+ project T124 is to achieve and demonstrate system-level solutions for such high temperature applications.

Cars are rapidly developing from purely mechanical to more complex and flexible electronically controlled systems. The increasing level of functionality will require growing circuit complexity. As the market will not accept premium prices for these highly complex systems on silicon, there is a substantial challenge for designers to provide technologically innovative and cost-efficient solutions.

Moreover, European carmakers are seeking to reduce assembly costs substantially. In particular, engine/transmission units will be treated as fully tested and calibrated items – including electronics, sensors, air intake and wiring – ready for delivery to the vehicle assembly plant.

This will only become a reality when the electronic control units (ECUs) can be mounted on the engine/transmission unit. These electronic components will have to sustain long-term operation in a harsh environment, where humidity, vibration and, most of all, high temperatures will impact reliability. Even higher temperatures and worse environmental conditions have to be met in other industrial applications.

The targeted operating temperatures for automotive applications range from 150° to 200°C, whereas state-of-the-art ECUs for engine and transmission control range between 125° and 140°C. Future oil drilling scenarios target even greater ambient temperatures – as high as 225°C.

Innovation driven by electronics

Market and legislative forces demand better fuel economy, improved safety and convenience and greater integration of vehicles into advanced transportation systems aimed at optimised environmental protection. Excellent electronics is a key competitive asset for the automotive industry. According to a recent study led by TRW, roughly 90% of vehicle innovation is directly driven by advanced electronic control systems while 75% of vehicle functions are controlled by software.

Weight and space limitations, together with wiring harness optimisation, demand higher integration density. Innovative basic technologies, such as advanced semiconductor chip packaging and assembly techniques, will allow considerable cost reduction. The need for higher integration density, together with the fact that electronic modules and functions are being

increasingly integrated into mechatronic units, inevitably leads to higher device temperatures.

Over the next few years, there will be a major growth in automotive electronics for engine/transmission controls, anti-lock braking systems (ABS)/traction control and steering systems (drive-by-wire). In those applications, car manufacturers will need components specified for ambient temperatures up to 165°C or even higher. Some applications for integrated mechatronic sensor systems will need chip components to work in temperature ranges above 200°C.

From chip to car maker

The MEDEA+ T124 HOTCAR project set out to achieve industrially relevant results by integrating a complete vertically structured supplier chain from the chipmaker to the car manufacturer. To ensure a competitive approach embodying innovative concepts and advanced industrial research, leading European competences have been included in the team – such as those of Atmel, Infineon and STMicroelectronics for chip development.

This mixed consortium structure is considered to be beneficial not only for wide acceptance of the proposed concepts by electronic system suppliers such as Schlumberger, Siemens VDO, Conti Temic and Valeo, but also to strengthen European leadership in automotive technologies. This is why car manufacturers – DaimlerChrysler and Fiat – are also involved in the project.

The HOTCAR project is organised in seven work packages: definition of mission profiles and demonstrators; silicon technology; advanced substrate materials; component packaging; interconnect technology; qualification and reliability methodology; and, finally, validation through application demonstrators.

Functional failure models are being developed through deliberate investigation of the technology limits. Fixed 'global' specifications are also being replaced by distinct mission profiles. This approach will ensure that the efforts of the chip designers, package and assembly experts meet the specific lifetime targets.

Market-mature solutions

HOTCAR builds on basic technologies and a generic chipset developed for a temperature range up to 200°C within the earlier MEDEA HiTeC project, as well as on the results of other R&D projects such as the European Commission funded REDHOT project.

The MEDEA+ project is pushing the results achieved by HiTeC to the next level of exploitation by focusing on system-on-chip (SoC) solutions, state-of-the-art microchips and other increasingly complex integrated circuits (ICs). This is being accompanied by investigations in the field of advanced packaging technologies to fulfil the requirements of high temperature applications in the automotive area.

Oil prospecting is another driving force for high temperature electronics. To achieve independence in the energy sector, many companies are drilling wells once considered non-exploitable or looking for alternatives to fossil fuels such as geothermal sources. The geothermal market and reservoir monitoring are strongly dependent on highly reliable electronics well above 150°C. Therefore, the availability of viable, reliable and cost-effective high-temperature electronic systems up to 250°C is a real need.

Consolidating extending lead

The results of HOTCAR will provide European chipmakers, systems suppliers and car manufacturers with cost-effective solutions in terms of chipsets, substrate materials, and package and interconnect technologies for high-temperature ECUs, ready for automotive applications. New architecture and new functionalities will make it possible to reduce fuel consumption and cut emissions to meet forthcoming European environmental legislation and to improve health.

It is also important for Europe to be the first to introduce such products on world markets to create jobs and to consolidate and extend Europe's innovative role in automotive electronics.

In this relatively small part of the worldwide electronics market, there is nevertheless a need for a standardisation of high temperature hardened electronic products. Standardisation activities are a key issue for controlling the cost of specific but relatively low volume electronic devices and therefore form an integral part of the HOTCAR project.

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