PROJECT PROFILE

2T204: End-of-life investigations for automotive systems (ELIAS)

TECHNOLOGY PLATFORM FOR PROCESS OPTIONS

Partners:

AMI Semiconductor
ATMEL
austriamicrosystems
Cadence Design Systems
CNRS LAAS
Daimler AG
Epsilon Ingénierie
Infineon
Robert Bosch
STMicroelectronics

Project leader:

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Key project dates:

Start: April 2007
End: March 2010

Countries involved:

Austria
Belgium
France
Germany
Italy

Electronics are playing an evermore crucial role in driving innovation in the automotive industries. Advances are crucial for traffic safety, cuts in carbon dioxide (CO_2) emissions and reductions in fuel consumption. As a result, reliability requirements for automotive applications are high and constantly increasing. The MEDEA+ 2T204 ELIAS project is developing accelerated test and simulation methodologies providing standardised predictions of component lifetimes and speeding introduction of new longer-lasting devices. As a result, higher quality systems will become available faster, helping to place the European automotive industry in the global vanguard and to safeguard employment in Europe.

The reliability of electrical and electronic components has been given extremely high priority by the European automotive industry. Integrated circuit (IC) users are demanding more severe mission profiles with ever longer durations. While Europe has excellent research competence in automotive technology, maintenance of its current world-leading position requires all the different industries involved to co-operate closely over the entire value chain.

A major goal for the automotive industry is to cut fuel consumption by further improvements in engine-control electronics and sensors. This will contribute significantly to European environmental goals such as meeting CO_2 limits set by the Kyoto protocol. Car safety is equally important for success in the global market. Development of intelligent, predictive safety systems is also crucial to achieve EU targets to reduce traffic casualties established in its eSafety programme 'intelligent car' initiative.

A key factor for the introduction of new automotive systems is an increasing reliability of new technologies giving ever greater functionality with decreasing failure rates.

Coupled simulations a problem

Basic methodologies to simulate thermal and electrical effects are already used in designing automotive circuits. However, until now, coupled simulations have often generated unsatisfactory results, and significant effort is needed to obtain the input data required. Operating temperature – a critical parameter for lifetime – is often determined experimentally by measurements that are not particularly reliable.

In addition, degradation mechanisms are not usually considered during simulation when predicting the lifetimes of smart power device. Although simulation tools are commercially available for the degradation behaviour of CMOS devices, they do not yet support smart power processes. Moreover, the lifetime of the extremely stressed power stages cannot yet be modelled satisfactorily; the first such models were only developed in the EU Sixth Framework Programme (FP6) ROBUSPIC project, which dealt with robust mixed-signal design methodologies for smart power ICs.

Furthermore, there are few research results available on the impact of the combination of strong temperature gradients and high currents that occurs during power-stage operation. Life-expectation models tend to be specific to a single failure mechanism and most express the meantime to failure as function of constant operating conditions rather than taking into account a variable environmental and operational loading.

Chip-package interactions have also become a critical factor affecting lifetime. Standard reliability tests such as high temperature storage or temperature cycling have become less effective as temperature – the main acceleration factor – cannot be raised sufficiently high above that required by the application itself due to the thermal constraints of the materials.

At package level, failures are caused by mechanical stresses resulting directly from the temperature variations. The temperature shift comes either from ambient temperature variation or from self heating. The latter has been tackled by integrating compact power cycling models into electrical simulators but lack of effective modelling means this is not particularly suitable.

An alternative is provided by REBECA-3D electro-thermal design and simulation software, which computes 3D temperature fields into the whole package. This is fast, versatile and suitable at package level but requires building a behavioural table – a complex operation that may limit the operating range covered.

Simulating lifetimes

The MEDEA+ 2T204 ELIAS project has therefore set out to perform the simulation of lifetimes for smart power circuits and their packages. The objective is to optimise smart power circuits in terms of cost, performance and reliability. This will make it possible to exploit the advantages of highly developed smart power processes effectively in the design of complete system-on-chip (SoC) solutions.

Key advances are expected in:

- Methods for the accurate measurements of key parameters impacting lifetime;
- Methods for time- and cost-effective prediction of the lifetime of semiconductor devices and their packages;
- Innovative measurement setups that support aging models for electronic devices and their packages as a basis for reliable lifetime simulation and prediction;
- Generation of aging models taking into account variable operational and environmental conditions;
- Development and improvement of accurate electro-thermal models using REBECA-3D software; and
- The design flow for circuits allowing efficient design for very low-failure rates over extended product lifetimes.

To achieve this, ELIAS has brought together a consortium of designers and technologists from five countries with a wide range of know-how covering device-failure mechanism, package-related failures – including many different materials – and failure models. The companies concerned provide an environment that can cope with the effects of temperature, stress, moisture, etc. to simulate reliability at component and at system level.

Standardised methods

An overall objective of the project is to create standard interfaces for reliability simulation that can be readily adopted by circuit-simulator tool vendors. The consortium will also be in a position to formulate standardised methods for reliability characterisation, requirements for characterisation equipment and acceleration methods.

In addition, the availability of aging data from a range of processes covering the various technology nodes and different process architectures introduced by the project partners will provide an unprecedented database for the validation of new aging models.

The major outcomes of this MEDEA+ project are therefore expected to be:

- The development of new tools to meet the demands of the international market to solve problems in increasingly extreme applications;
- A general widening of knowledge about electro-thermal coupling in power electronics; and
- The availability of databases on the ageing phenomena of components.

The result will be an improvement in the overall reliability of electronics, especially for automotive systems, and in the competitiveness of European semiconductor and systems companies.

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