PUBLISHABLE SUMMARY

Automotive Tested High-voltage

Embedded Non-volatile memory Integrated SoC

Grant Agreement number: # 216436

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Project partners:

Objectives

More than 20% of the value of each car already comes from embedded electronics. Keeping costs and space for additional functionality low requires further integration of electronic components such as low and high voltage devices and memory on a single System-on-Chip (SoC).

SoC technologies for segments with lower reliability requirements are already available. However, there are no cost-effective technologies yet combining all of the harshest automotive reliability requirements for full SoC integration of powertrain ICs for engines, starters, alternators, etc. This barrier to powertrain IC SoC integration inhibits cost reduction and introduction of more fuel-efficient cars.

The purpose of ATHENIS is to provide proof of concept for the industry's first SoC technology platform that can surmount these integration barriers. The ATHENIS SoC technology platform is intended to be the first in meeting the combination of all of the harshest requirements including full reverse polarity capability at the low cost of CMOS, application voltages up to 120V, currents up to 10A, temperatures up to 200°C, embedded non-volatile memory (eNVM), chip-level ESD up to >8kV HBM, and high logic gate densities.

Approach

Creating the ATHENIS technology platform is achieved by combining HVCMOS technology from austriamicrosystems AG (AMS) with MEMS-based 'Nanomech' embedded Non-Volatile Memory (eNVM) technology from Cavendish Kinetics.
As a reference existing Fowler-Nordheim tunnelling based embedded memory technology from AMS is investigated and further developed in combination with AMS 0.35µm HVCMOS.
Innovative (patent pending) add-on technology modules such as reverse polarity HVCMOS and >8kV ESD structures for HVCMOS as well as automotive extensions for Nanomech are also developed.
An alternator-regulator demonstrator with and without eNVM was selected for a worst-case proof of concept. eNVM will enable 'flexibility' to software-configurable alternator systems for multiple car platforms and improve energy efficiency during operation. At completion of the ATHENIS project in 2010 we will demonstrate a new type of intelligent and flexible alternator regulator enabled by the ATHENIS platform. This new generation of alternator regulators will reduce vehicle fuel consumption and CO2 emissions by 1% - 2%.

The consortium lead by austriamicrosystems (AT) includes Valeo (FR), Cavendish Kinetics (NL,UK), Fraunhofer (DE), TU Vienna (AT) , University of Ferrara (IT), MASER Engineering (NL), and Fondazione Bruno Kessler (IT) as partners to fully cover the value chain.
Within the consortium Valeo Electrical Systems provides system specifications, system development and system evaluation. Austriamicrosystems and Cavendish Kinetics provide High-voltage and embedded memory technologies for the ATHENIS platform as well as circuit design capabilities for the demonstrator. The other research and development partners contribute the required novel characterization, reliability, test, and simulation methodology.

Results

Highlights / summary

Based on the ATHENIS platform and demonstrator specifications completed in the first period the development work progressed in the 2nd year with the objective of platform and demonstrator validation.

The test chip for the challenging alternator regulator part including a high voltage driver with very low on-resistance (125mΩ at 150°C) and 8A output was completely integrated in a flexible SOC concept in connection with an FPGA. Measurements verified the correct functionality of the entire system up to 180°C, the standby current, the communication, the slope control and the reverse voltage protection on the system. New 8kV ESD protection based on newly developed structures was successfully implemented on the demonstrator.

Based on extensive TCAD simulations an extension of the HV-process platform by reverse polarity HV transistors was successfully demonstrated. This enabled the first time a fully isolated reverse polarity NMOS device switching 70V below substrate potential in a HV-CMOS technology platform.

Methods for RDSON improvements for HV-devices have been further developed and demonstrated improvement capabilities of 30% RDSon reduction implemented on a 0.18µm HV-CMOS platform compared with the former 0.35µm platform. In addition the extendibility of the 120V lateral HV-CMOS concept was demonstrated successfully on the 0.18µm technology platform at the low cost of HVCMOS with chip sizes comparable to more costly BCD.

For embedded Non-volatile memory integration into the ATHENIS platform the MEMS based Nanomech and the conventional Fowler-Nordheim tunnelling based memory were developed and further characterized. In parallel new advanced NVM characterization methods and model development was accomplished. The conventional FLOTOX based memory concept demonstrated very good reliability extending its application range to 180°C suited for automotive environments.

Based on first high temperature reliability investigations a new Nanomech cell layout was developed demonstrating programming and data retention capabilities over an outstanding range of -150°C to 300°C thus far exceeding the usual operating temperatures of automotive electronics.

Specific improvements for Technology CAD simulations to further improve predictive capabilities of ATHENIS HV technology simulation were pursued in parallel. The threshold voltage of MOS devices is still difficult to predict by Technology CAD due to limitations in modelling Boron diffusion. Characterization methods to determine exact Boron profiles have been further improved and calibration with test-structure results enabled further improvements that will be published.

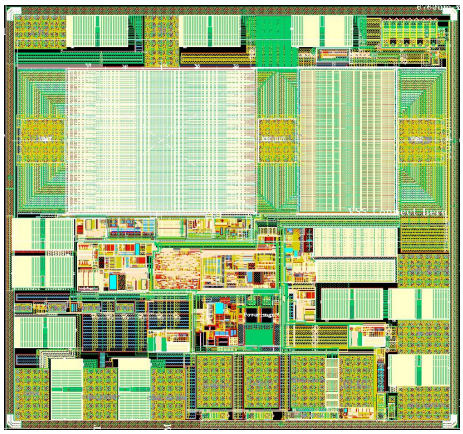
The modelling of NBTI (negative bias temperature instability) for transistors which is critical for high temperature applications addressed by ATHENIS has already gained worldwide recognition. It was in the last period further improved and is now coupled with hot carrier degradation modeling. Both the NBTI as well as the HC model have been developed based now on similar microscopic descriptions of the reaction kinetics. This will enable for the first time the prediction of reliability characteristic of a wide range of devices by simulation as will be shown below.

Impact

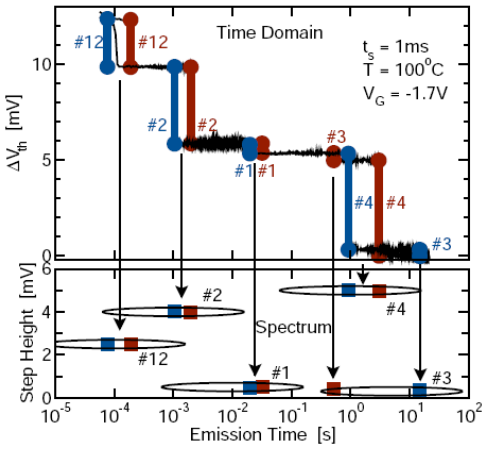
The new generation of alternators enabled by ATHENIS will reduce fuel consumption and CO2 emissions by 1-2% together with faster system optimization and development cycles. Many further products for energy efficiency will be enabled. Product and technology differentiation will enable additional employment in R&D and manufacturing by industrial partners. Knowledge from research like simulation and reliability will be disseminated.

Further information on ATHENIS is available via http://www.athenis-fp7.eu/ .

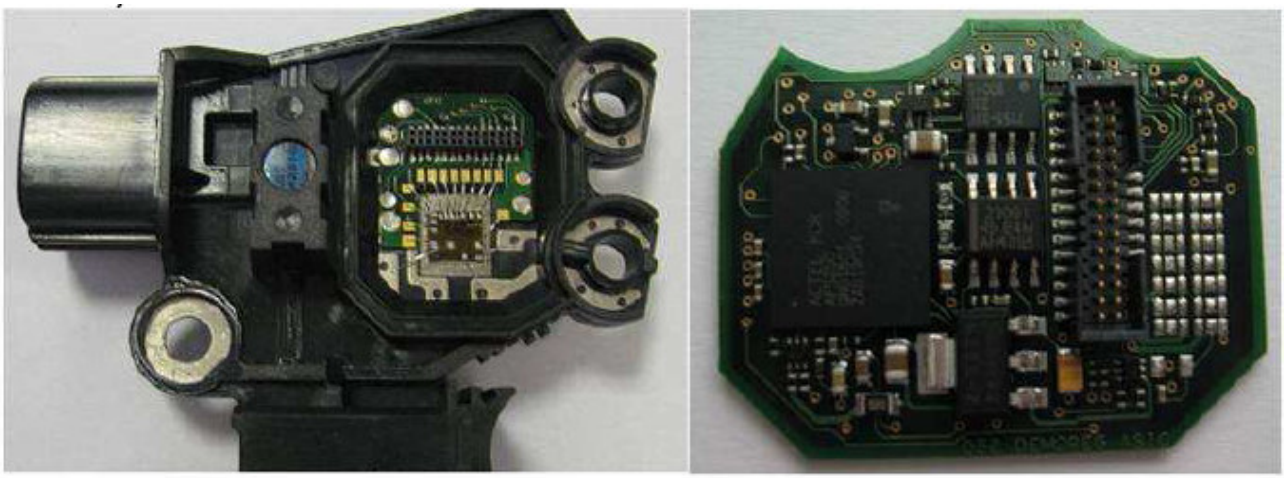
Figures



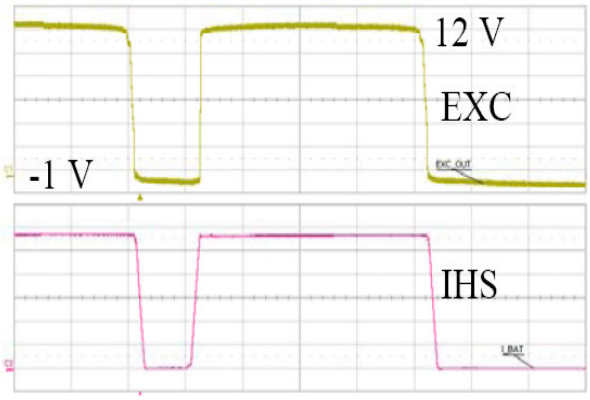
ATHENIS demonstrator layout



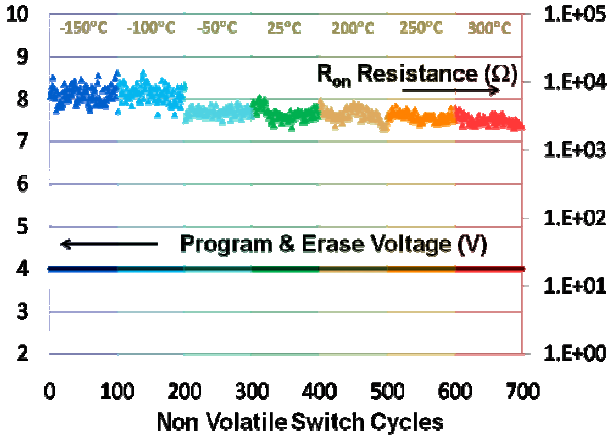
NBTI recovery traces



brushholder for alternator demonstrator with flexible FPGA control



Alternator demonstrator switching



Nanomech NVM cycling up to 300°C