PROJECT RESULTS

CA403

Combining design solutions ensures future systems-on-chip reliability [RELY]

Systems-on-chip (SoCs) become more complex and prone to failure as the integration of new functions and devices increases, dimensions decrease, and operating conditions get more extensive. In addressing these issues, the RELY project found ways and means to maintain reliability and risk at acceptable levels.

One of the main problems with integrated circuits (ICs) approaching atomic dimensions is the high susceptibility to miniscule interferences and deviations. Each new generation leads to larger production fluctuations and ageing, which deteriorate properties and therefore the functionality of new systems-on chip (SoCs). Their complexity is rapidly increasing as more functions, devices and sensors/actuators get integrated, and operating conditions become more extensive. However, safety-critical components still have to remain reliable, despite increasing ageing and failure sensitivity.

Managing reliability while reducing dimensions and costs

Mainly focusing on the avionics, automotive and medical fields, RELY's two main objectives were to ensure future SoCs reliability by combining different solutions along the entire value chain; and to make SoCs that have a new level of functionality and complexity through increased reliability possible for a reasonable price. In addressing these issues, the RELY project has also made risk less of an academic issue, and more predictable and manageable.

These application-based goals can be translated into the following product development areas of focus:

1. Prediction of reliability at all phases of system design;
2. Design and architectural solutions that increase system reliability;
3. Reducing chip dimensions and cost-overheads.

In early and fast reliability-prediction, RELY's research led to a combined model for two of the most relevant effects: Negative Bias Temperature Instability (NBTI); and Hot Carrier Degradation (HCD). For three further relevant effects – Time Dependent Dielectric Breakdown (TDDB), Soft Breakdown (SDB), and Electro-migration – the models have been characterised by, and evaluated against, silicon measurement-data, thus increasing the model's accuracy significantly.

In addition, RELY delivered two new methodologies: to select optimal design parameters (in terms of functionality as well as reliability) for analogue circuits; and to generate degradation models for all available tool interfaces directly from the characterisation data (thus simplifying drastically the effort to establish a degradation model out of the measurement data, and allowing commercially available tools to be used).

Increased system reliability

RELY also developed several run-time reliability-management strategies (using these prediction methodologies), such as sensor redundancy schemes; run-time degradation sensing; sensor output data aggregation; and reliability management using a dedicated reliability layer, or selective hardening techniques.

The project also presented a highly reliable high-temperature technology which increases electro-migration susceptibility. In addition, it developed techniques to prevent fatal field returns due to early detection in the design process far before tape-out; and a new methodology and circuitries which can detect quality problems in the fab hundred times faster.

Reduction in size and cost issues

Thanks to the overdesign of its reference circuit, RELY was able to demonstrate a reduction of 20% in power overhead in the analogue part of a test chip used in medical devices, and a 37% reduction in the digital part, when subject to the

PROJECT CONTRIBUTES TO

- Automotive and transport
- Health and aging society
- Design technology
- Sensors and actuators
- Manufacturing science
- More than Moore
- More Moore

Technology node / 350nm to 28nm

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PROJECT LEADER

Georg Georgakos
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KEY PROJECT DATES

May 2011 - April 2014

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same reliability target. The project also developed a redundant (thus highly reliable) sensor array for avionic applications in extremely harsh environments, demonstrating how to build reliable systems from unreliable components, especially sensors. These techniques can also be used to maintain the required reliability at lower costs, rather than further increasing it. Under these constraints, it is possible to find solutions that ensure high reliability, while minimising the design overheads in terms of area, power or performance. All these will finally reduce the cost of a reliable system – making smaller, more powerful technologies more attractive for reliable systems, and thus ultimately leading to improved, and even completely new, reliable systems.

Finally, in addition to demonstrating actual cost-reduction, the project also improved the design methodology to generally reduce the cost of reliable system design. A better understanding of the correlation between NBTI and HCD led to an improved validation methodology. The 'pessimism' of long-term NBTI and HCD prediction can be reduced by a factor of two, generally leading to a huge cost-reduction by avoiding unnecessary overdesign. A methodology was also developed to optimise yield and reliability of analogue circuit blocks automatically and ultimately reduce costs.

Impacting key European industries

In providing a better understanding of ageing due to various reliability mechanisms, RELY addressed the special semiconductor requirements of the aeronautics, space and defence industries. In particular, applications in aeronautics need an extremely high level of robustness, reliability and quality. The impact will also be felt in other domains where high reliability is critical. For example, SoC applications in avionics, medical, industrial automation, and where automotive and telecom infrastructure requires uninterrupted operations. Another example is in the medical area, where new high-reliability implantable devices operate under difficult (low power) conditions – a new field of business opportunities.

RELY is considered a well-recognised European project, addressing the central issues of European integrated device manufacturers and application designers. Thanks to this and other European and national projects, Europe is clearly dominating worldwide research in terms of ageing effects, robustness, and reliability: The project is therefore of broad relevance to major European industries, and its results will strengthen the established position of the consortium partners in their specialist fields, while the dissemination of the results will ensure broad distribution of the new methodology.

RELY's strong position takes research to the next step

RELY's technical achievements have resulted in four patents, two books and articles in 14 trade journals. The project was represented at 114 trade fairs and numerous tutorials, and project participants were invited to talk at conferences and contribute to workshops.

Notably, RELY's position is further strengthened by a total of eight direct or indirect national and European follow-up projects, reinforcing and expanding RELY's research base in such fields as standardisation. Importantly, in taking into account such additional physical aspects as the coupling between variation and degradation, these new follow-up projects will firmly bind RELY's research to the needs of specific target applications, like automotive safety.

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