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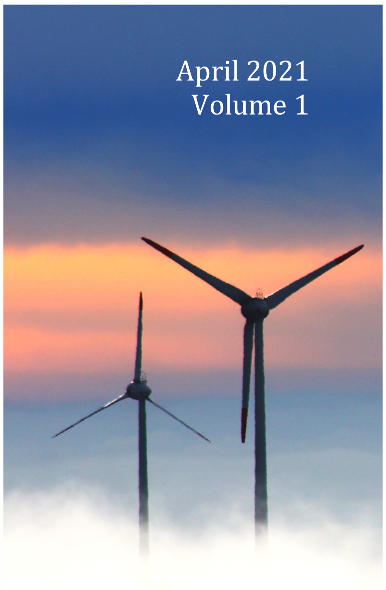


iRel40

Intelligent Reliability 4.0

Newsletter Year 1

"Intelligent Reliability 4.0" (iRel40) has the ultimate goal of improving reliability of electronic components and systems by reducing failure rates along the entire value chain.

The Europe-wide research initiative "Intelligent Reliability 4.0" (iRel40) aims to improve the reliability of electronic systems and micro(nano)electronic components. Coordinated by Infineon Technologies AG, 75 research and industrial partners from 13 countries are joining their forces to achieve this goal.

iRel40 adopts a holistic approach to optimizing the reliability of microelectronic systems along the entire value chain – from the wafer to the chip and the packaging and finally to the system and hence to the actual application. The aim is to significantly reduce failure rates and thus improve product quality and lifetime. This approach also contributes to more sustainable management of our natural resources.

Experts from science and industry in Europe are working together to achieve this goal. They are relying on the latest insights and methods in material research and failure analysis, including modeling and simulation, as well as artificial intelligence. The project is divided into eight work packages that deal with aspects such as requirements, theoretical principles, materials, test methods, and pilot applications.

Inside this issue

Facts & Figures

Partners: 75
Countries: 13
Budget: 101.8 Mio €
JU Funding: 24.5 Mio €
Project Start: May 1st, 2020
Duration: 36 months
Coordinator: Infineon Technologies AG

Consortium constellation

Partners plan to amass costs of more than € 100 Mio. requesting roughly € 24.5 Mio. of European and national funding. Additionally, all partners invest more than 50% of the budgeted costs from their own funds clearly demonstrating their very high commitment to the iRel40 project.

ABOUT THE PROJECT

Project Objectives

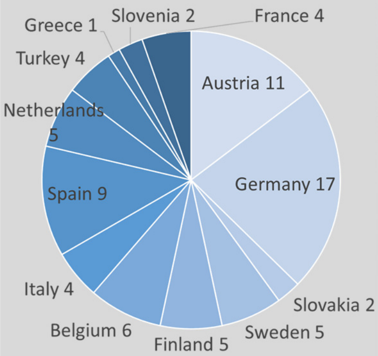
Our daily life is deeply affected by the penetration of all types of electronic aids and we must rely on their proper functionality not only in regular operating mode. Transport and Smart Mobility, the Digital Industry, our education and healthcare systems, communication, the energy sector, industrial production, all these applications are built upon highly complex electronic components and systems (ECS). It is commonly expected that electronics, and mainly the hardware, is "just" functional and reliable. This is particularly important, since malfunctioned electronics may affect our life or well-being. However, this causes extreme challenges because these ECS often become part of systems, reaching a complexity, which can hardly be understood by individuals. The ECS value chains in many domains are nowadays driven by revolutionary transformations coming along with the digitalization.

iRel40 has one primary objective: **Improve the reliability by reducing the failure rate.**

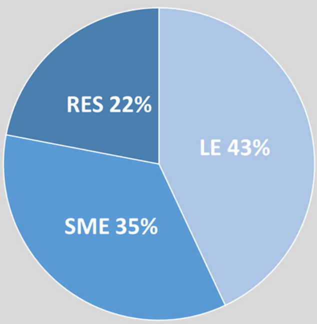
Hence, iRel40 will be a nucleus for a new European reliability expert community, enabling differentiation in the ECS Industry.

iRel40 partners invest more than 50% of the budgeted costs from their own funds, which clearly demonstrates their commitment to the iRel40 project.

75 partners from 13 European countries



Partner structure



The strategically measurable objectives:

Objective 1

Define needs and requirements for future ECS applicants to drive improvements and prediction of reliability along the value chain including chip, package, board/system - to foster Europe's competitiveness in ECS.

Objective 2

Implement data value chains and cross component data analytics to speed up the learning curves by 30%.

Objective 3

Double the predicted lifetime for specific materials and load conditions for ECS applications.

Objective 4

Early detection of unexpected quality relevant events along the ECS value chain by advanced and innovative control concepts.

Objective 5

Reduce the failure rates by 30% and enable the lifetime prediction with connected and new test concepts along the ECS value chain.

ABOUT THE PROJECT

Consortium as a whole

The iRel40 partnership is a perfectly balanced, multidisciplinary industry-research consortium, well dimensioned to meet the research challenges and to reach the project objectives, representing 75 partners from 13 European Member States and associated countries. Amongst them are highly qualified partners:

- Experienced coordination by a large industry partner
- Well-known large industries with worldwide reputation, including semiconductor manufacturers
- Specialized SMEs with skills for the project execution and integration of SME cluster
- Research institutions and academia having a distinct focus on reliability

All iRel40 contributors are well-established organizations with an outstanding reputation forming a consortium with complementary skills and expertise. Many partners know each other from various cooperation activities, an essential basis for good communication and administrational and technological coherence. In addition, many new contacts were established between partners who have never worked together before. Each partner has the ability and willingness to take responsibility for a vital project part and to accomplish the related tasks in the best possible way. The consortium of iRel40 is aligned along vertical supply chains and different industrial domains reflecting all relevant capabilities to fulfil the envisioned project goals. This spans competences, infrastructures and expertise from automotive manufacturer, transportation industry, semiconductor manufacturer, aeronautic industry, assembly industry, consumer industry and power electronic oriented research institutions including universities.

Benefits of iRel40 for the average European citizen

The project provides reliable and cost-efficient development and manufacturing skills for European ECS eco-system. Europe has a long-lasting reputation in industrial competence manifested in highest quality and reliable products. iRel40 will push these competences by advancing beyond state-of-the-art in the selected domains and, at the same time, strengthens the competitiveness of European industry and research in a unique European reliability consortium bringing experts from academia and manufacturing together. This is why iRel40 will generate and secure employment and welfare in Europe.

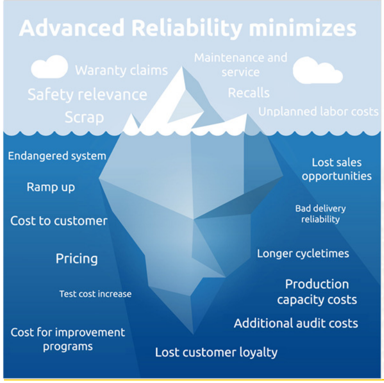
Why do we need to improve reliability?

If we as consumers buy products that don't work, we will change suppliers or manufacturers sooner rather than later. The customers at the end of the ECS value chain behave the same way.

There are usually only a few reported effects when talking about unreliable products, but there are a lot of critical implications evident for semiconductor and electronics companies.

By minimizing these effects, the iRel40 makes the "ice" melt!

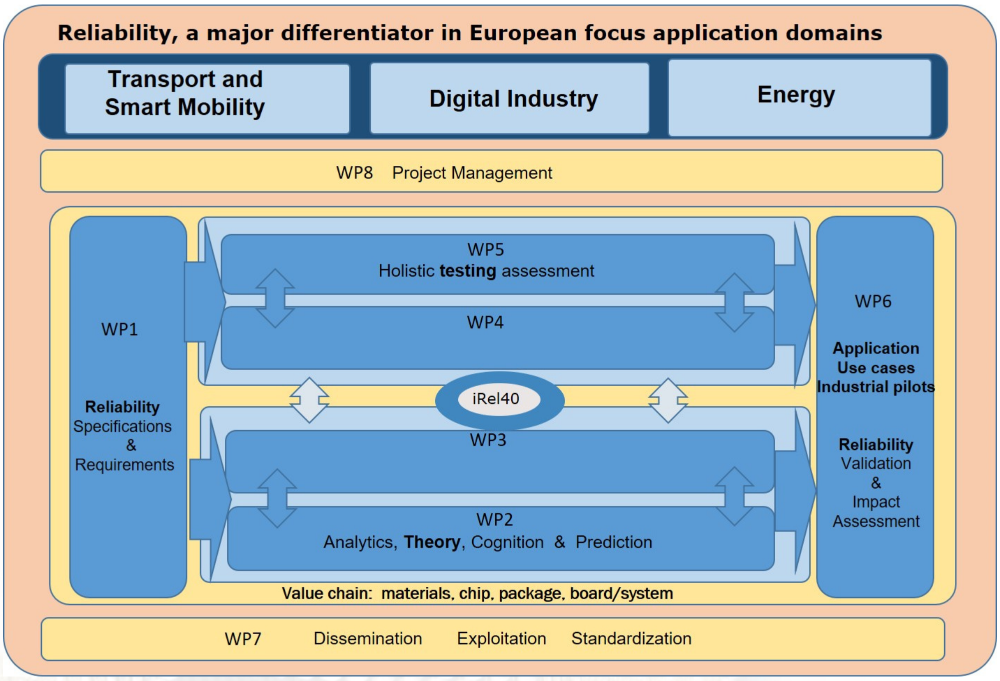
See: www.irel40.eu



ABOUT THE PROJECT

Project organisation

iRel40 implies a classical work package structure consisting of 8 work packages. The work package structure is well aligned with achieving the overall iRel40 objectives and thus ideally supports the entire supply chain to foster the reliability attempts.



The results of the project will be utilized in 16 Use Cases and 18 Industrial Pilots.

8 Work Packages **16 Use Cases** **18 Industrial Pilots**

More than 30 Industrial Pilots and Application Use Cases demonstrate outstanding innovation potential of the iRel40.

The iRel40 contributions to strengthen industrial competitiveness

- Reliability is a key enabler for bringing European electronic products into the market
- Time to market is a key factor during commercialisation of innovations. Improved analytics and theory together with knowledge generation in this large consortium will allow faster development of new products
- „Quality 4.0“ has outstanding impact to produce semiconductor products in Europe
- „Testing 4.0“ includes new tests and faster test methods that will improve time to market
- Pro-active virtual Design for eXcellence (DfX) strategies based on virtual techniques will lead to the advantage that the development cost will be paid back very fast by the extra profit gained by being first supplier
- Functional safety and prognostic health management have high impact in competitiveness in automotive, industrial and infrastructural electronics

ABOUT THE PROJECT

Use Cases (UC) and Industrial Pilots (IP) within iRel40

Domain Digital Industry

UC DI-1: Stretchable sensor

UC DI-2: VCSEL based emitter (LIDAR)

UC DI-3: Development of a smart/reliable LED driver system

UC DI-4: Reliability and aging prediction for an integrated stress sensor

Domain Energy

UC E-1: Smart/superconductive sensoring system for condition assessment of electrical and electronic power devices

UC E-2: High reliability power electronic systems with active health-monitoring

UC E-3 Material development and testing for component protection

Domain Transport and Smart Mobility

UC T-1: Innovative LED driver IC for ADB (Advanced Driving Beam)

UC T-2: Fast commutation GaN-IC for LIDAR applications

UC T-3: Smart condition monitoring for the in wheel propulsion system

UC T-4: Backside illuminated optical sensor

UC T-5: Prognostic and health management for small series electric vehicles

UC T-6: Airport weather radar demonstrator

UC T-7: Estimation of electronic components failure behavior influenced by operational conditions in transport & smart mobility

UC T-8: Mobile transceiver for wideband outdoor communication in millimeter wave

UC T-9: Material preselection to ensure high 0h-quality of the package after manufacturing

Industrial Pilots

IP-1: Smart digital twin testing environment for digital hardware

IP-2: Application of image processing techniques in combination with machine learning/deep learning methods to enable the automated classification of defect density images during production

IP-3: New induction cooktops

IP-4: Pan-European quality pilot line

IP-5: Systematic process & equipment stability improvement enabling Industry4.0 in module fabrication

IP-6: Conditional burn-in

IP-7: Wafer-level packaging with reliable hermeticity

IP-8: A hybrid methodology for monitoring the health of fuel tanks in hybrid vehicles

IP-9: Electric motor failure detection and diagnostic approach based on motor parameter identification

IP-10: Mixed signal system validation – forced activation of field returns by application of artificial intelligence techniques

IP-11: Application of a design limits based, predictive design approach for the design of a reliable embedded in laminate power module

IP-12: Pressure sensor using C-SOI®

IP-13: Increased reliability of automotive power electronics through embedded AI for self-diagnosis combined with physics-of-failure models

IP-14: Enhanced cross-site wafer-level reliability test and methodology for reliability prediction

IP-15: Reliability driven assembly pilot for miniaturized pressure sensors

IP-16: Reliable smart power for back end of line

IP-17: Reliable xMR- sensor based current measurement module

IP-18: Industrial ion traps

PROJECT ACHIEVEMENTS

First-year developments

WP1: Reliability Specifications & Requirements

The aim of WP1 is to define needs and requirements for future ECS applications to drive improvements and prediction of reliability along with the chip, package, board/system value chain. In the first project phase, three use case workshops were set-up to confirm and check the 34 use cases and to align on precise working modes. In addition, two capability workshops were organized for all partners to share and align capabilities of the partners in respect to methods, modelling and simulation as well as processes and materials. First activities working towards the set-up of a pan-European network have started.

WP2: Analytics, Theory, Cognition & Prediction

The purpose of WP2 is to develop methods, algorithms, and models to achieve cognition and prediction in the reliability methodology for electronic devices, components, and systems. The work is organized in four different tracks: data value chains, AI-based methods, physics-based methods, and the combination of AI- and physics-based methods to achieve prognostics of failures. All tracks have started during the first year but the main focus has been on the data value chains. The implementation of cognition and prediction in the reliability methodology requires large amount of data from the development and the fabrication phases as well as from the in-field use. This data needs to be collected, stored, and processed in a way that allows the proper data flow along the entire value chain and the development and implementation of a complex AI model. During the first year of iRel40, different methods for big data flow and storage have been developed.

Reliability isn‘t everything, but without it, everything else is nothing.

WP3: Advanced Functional Materials & Interfaces

The ongoing trend towards system-on-chip and system-in-package has been accompanied by integrating different and more complex functionalities that involve a significant number of materials. Simultaneously, the miniaturisation leads to higher requirements with respect to extended mechanical, thermal, electrical, and environmental loads combined with still higher demands for reliability. WP3 responds to these challenges with a dedicated focus on materials in a multidimensional way by investigating the use of new materials, their processing, testing, and simulation in an integrated environment with a strong emphasis on reliability and lifetime. New and innovative test vehicles and strategies, as well as analytical methods for materials and interface characterization are under development and will be tested and implemented to monitor critical key processes.

WP4: Production & Development Excellence

WP4 is dealing with development of different process in semiconductor production, sophisticated methods for learning about reliability utilizing huge amounts of product data from the entire life cycle. It also deals with innovative diagnostic concepts during production making use of digital information and innovative decision-making procedures. The work in the WP4 is realized within 7 tasks and 84 individual topics and activities of partners, which are unified by the overall target to improve specific aspects of reliability in their segment of competence. In the first months of the project, the work was focused to specify all activities to make them transparent, structured, and plannable. A clear communication structure was established which enabling the teams now to work according to a transparent system of project plans, which can be regarded as a red line through the upcoming phases of iRel40.

First-year developments

WP5: Holistic Testing Assessment

Within this work package, the focus lies on all reliability tests along the value chain. New test options that cover real-life conditions of electronic components and systems will be needed to fulfil the challenging requirements for reliability. Therefore in WP5, the test methods for on-chip, package, board, and system-level are developed and optimized in terms of reliability failure coverage. Additionally, new tests including the development and validation of innovative test structures are implemented. Quality is a key aspect of customer-supplier relations. Thus, an increased test coverage at various levels of the supply chain (e.g. new test options for mechanical properties and enhanced test models for a longer lifetime of systems) will strengthen the competitive advantage of the European ECS industry.

Customer satisfaction is seen as a key differentiator and increasingly has become a key element of business strategy.

WP6: Application Use Cases, Industrial Pilots - Reliability Validation & Impact Assessment

WP6 aims to demonstrate the technical advances developed in the framework of WP2 to WP5 in relevant industrial pilots and application use cases, aligned along the value chain from wafer to chip-package-board/system. WP6 provides the general overview of all results of the iRel40, as the validation and impact assessment of all use cases and industrial pilots are included in WP6. The core part of this WP6 will be carried out in the second half of the project.

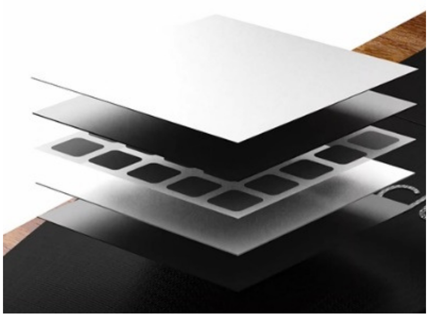
WP7: Dissemination, Exploitation and Standardization

WP7 focuses on the dissemination of the project results and activities. In addition, WP7 aims at exploitation and standardization. In the first year of the project, Corporate Identity including project website, logo Facebook, LinkedIn & Twitter social media accounts were completed. The project website is www.irel40.eu, and the visitor can find on it the links to associated iRel40 social media. Furthermore, a project teaser video was prepared to present the project vision and objectives in a way that is easy to understand for all target groups and stakeholders. The video is accessible at www.irel40.eu/news-detail/irel40-booth-at-virtual-efecs-2020. Mobility.E and Industry4.E. initiatives were joined. Several internal workshops were held to clearly communicate use cases across the consortium of 75 partners.

SELECTED TECHNICAL INNOVATIONS

First-year achievements

Innovations in selected Use Cases

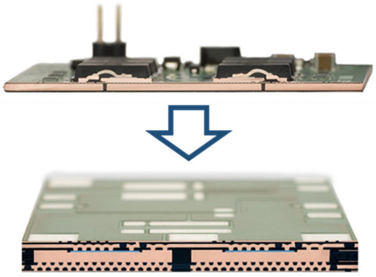


Use Case DI-1 aims at the development of a stretchable sensor. These sensors are typically used on top of soft, 3D-shaped, or moving surfaces to sense for example touch, pressure, and temperature with spatial resolution. Stretchable sensors utilize conductive printed structures on a stretchable substrate and sensor data acquisition electronics on a rigid Printed Circuit Boards. The focus of the project is on the reliability of the integration of stretchable and rigid structures.

In the first year of the project, current state analysis has been conducted and potential solutions for interface structures, manufacturing methods, and testing methodology have been identified for development. Test vehicle concepts have been agreed between the partners and the first test vehicle designs are released for manufacturing.

Use Case E-1 aims at the developement of a smart magnetic sensor system for condition assessment of electrical and electronic power devices. Before the actual failure by a full electrical breakdown, partial discharges (PDs) occur in or along the interface with electrical insulation in power electronic modules and high voltage (HV) equipment. These PDs are precursors of imminent failure and can be detected by the sensor sometimes months before failure. This can enable timely replacement without interruption of functioning.

In the first year of the project, the principle has been described, literature studies carried out and a study has started into the requirements of the sensor. With power electronic modules the envisaged sensoring would be close to the modules; for HV the source will be more remote from the sensor, but the signals are expected to be stronger. As the sensor is aimed to have no galvanic contact with the measured objects, it should pick-up (electro)magnetic signals. The merits of the superconductive sensors are being explored.

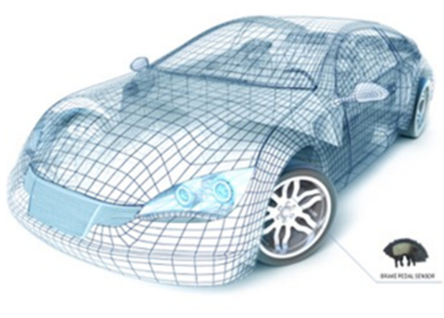


Use Case E-2 aims to develop advanced power electronic systems by employing embedding of power semiconductors as bare dies directly into the PCB, which promises an improved electrical and thermal performance and thus increased the lifetime.

In the first year of the project work, the specifications of test vehicles and demonstrators were defined. The partners have been working on the concrete design, such as the PCB buildup, selection of material, die attach technology and analysis methods.

Use Case T-2 aims to demonstrate the potential of a monolithically integrated GaN circuit (GAN-IC) to be used as a safe and reliable driver in the next generation of LIDAR (Light Detection And Ranging) systems.

In the first year of the project, the focus was on the critical process modules development and on the preparation of the documentation needed for the circuit design. Additionally, epitaxial growth recipe development on SOI substrates has been done, with a focus on (Al)GaN epitaxial stack thickness reduction, bow control, and Si substrate thickness reduction. The specifications for the use case demonstrator have been defined.



Use Case T-7 aims to estimate how electronic systems are going to behave depending on the operational context in which they operate. For that Artificial Intelligence (AI), simulation and testing techniques will be employed.

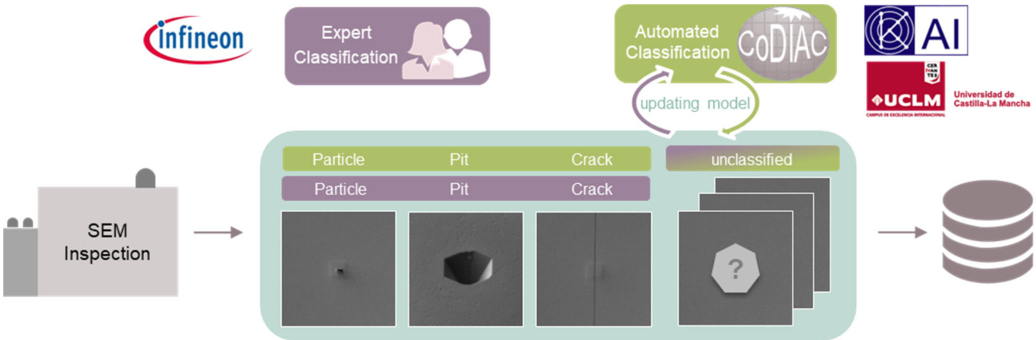
In the first year of the project, the partners have been working on the creation of reliability-oriented data infrastructure and database by the definition of procedures and technologies to employ. Several advances were achieved regarding the identification of critical features that influence the failure behaviour of the electronics, and how AI-based reliability models are implementing this information.

First-year achievements

Innovations in selected Industrial Pilots

Industrial Pilot IP-2 aims to develop an automated classification procedure for defect density images from the semiconductor industry. Machine learning, deep learning, and computer vision methods are investigated and adapted to the needs of SEM image data.

In the first year of the project, historical data (i.e. images) from the SEM inspection tool have been reviewed and important meta-information provided by industrial experts has been collected. A first representative data set has been prepared and shared among all IP-2 project partners.



Industrial Pilot IP-3 aims to improve the reliability of electronic components of induction hobs. It was found that these specific components could be subject to different levels of stress than previously expected.

In the first year of the project, the main variables and parameters that can influence the reliability of the components were defined. The methodology of acquisition of these data was set.

Industrial Pilot IP-4 aims at novel approaches across multiple wafer fabrication technologies. Infineon Dresden is running one of the Europe's largest and most automatized wafer fabrication sites. Here, the highest quality and reliability are already part of the zero defect culture. Novel technologies and ever-increasing complexity in the product mix are now calling for the next generation of wafer development and production approaches. Infineon Dresden participate together with several iRel40 partners in IP-4 and provide their expertise in laser-based surface modification, in development of software and electronics for metrology, in laser equipment & systems, and in AI-enabled statistical analyses.

In the first project year, important experiments were launched and pursued in the labs and at the sites of partners involved in IP-4. In the further progression of the project, the results will be developed towards their application in the high-volume wafer production at Infineon Dresden.

Photo: High-volume wafer fabrication at Infineon Dresden

SELECTED TECHNICAL INNOVATIONS

First-year achievements

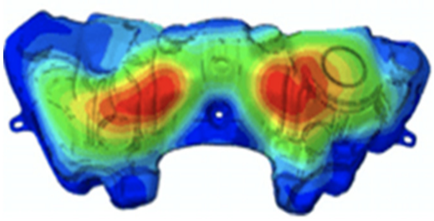
Innovations in selected Industrial Pilots

Industrial Pilot IP-5 aims to develop systematics to improve process and equipment stability for enabling Industry 4.0 capabilities in module fabrication. The target of this Industrial Pilot is to implement automated failure detection and prevention measures triggering auto-stop and automated corrective actions. Thus, a production with minimal human dependency can be realised to achieve the next level of quality.

In the first year of the project, the concept development for systematically assessing assembly process stability and equipment stability to identify critical process parameters has started. Critical parameter registers are set up for the majority of backend manufacturing processes. The control tool definition has been accomplished for all key processes.

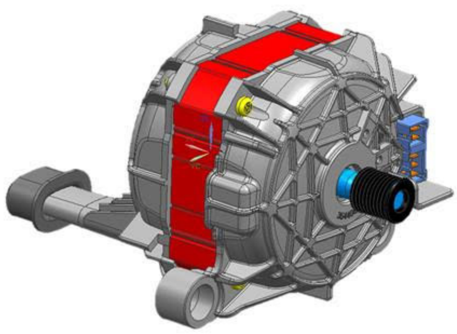
Industrial Pilot IP-6 aims to reduce the burn-in of semiconductor devices with the help of AI-methods. AI can help to identify the specific burn-in requirements per lot. The quality target for early failures is still kept.

In the first year of the project, the focus was to specify the method to be developed. Furthermore, partners started with lot data preparation and analysis.



Industry Pilot IP-8 focuses on monitoring the health state of fuel tanks in hybrid cars. For this type of cars, the tank needs to be constantly monitored in order to accurately detect deviations and trigger early warnings in case of safety risks. It is critical to detect the pillar integrity hence its capacity to limit the fuel tank deformation.

In the first year of the project, the research activity focused on the identification of electronic components and systems (ECS), compliant with safety requirements, regulations and technological constraints, capable of monitoring the tank integrity. For such ECSs, the relevant parameters for monitoring their health status were identified. Finally, an initial proof of concept for monitoring the tank integrity is under development .

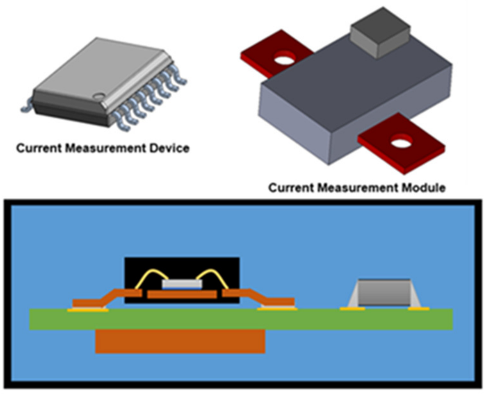


Industrial Pilot IP-9 aims to create a new test vehicle performing a fully automatic quality test of electric motors and to develop AI-based feedback algorithm from an aging test for correction and prediction of optimised threshold values.

In the first year of the project, the IP-9 team initiated the analysis and design of a novel test set up for the electrical motor production line, carried out research of the requirements and the subsequent design constraints concerning the signal acquisition, data transfer, data pre-processing and data analysis.

Industrial Pilot IP-17 aims to increase the reliability of the Anisotropic Magneto Resistive Current Measurement Module. The reliability of the device will be increased also for harsh environments with a focus on reduced offset drift over a lifetime.

In the first year of the project, special test vehicles to perform aging tests for the investigation and understanding of the relevant failure modes were designed and assembled. Based on these results a first prototype of the current sensor module will be designed and build up.



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