Project CHARM – Short Summary

Digitalization has been identified as one of the key enablers for renewal and competitiveness of European manufacturing industries. Harsh environmental conditions of the manufacturing processes and user environments are a severe challenge tackled by the ECSEL-IA 2019 project initiative CHARM, by developing sensor solutions to tolerate the conditions. The project solves real industrial challenges for reliable real-time monitoring of manufacturing processes, precision measurement and maintenance. The synergies and impacts come from similarities in the technology solutions of sensing and cloud connectivity for the different applications. CHARM includes use cases represented by innovative enterprises which are market leaders in their own fields: mining (Sandvik Mining and Construction, FI), paper mills (Valmet Technologies, FI), precision measurements (Sylvac, CH), solar panel manufacturing lines (Applied Materials Italia, IT), nuclear power plant maintenance (ÚJV Řež, CZ), and professional digital printing (Canon Production Printing Netherlands, NL).

The technologies developed include novel multi-gas sensors, robust high temperature sensors, sensors and wireless power transfer systems for paper machine rotating suction rolls, advanced vision system for temperature measurement in drying ovens, and a robust highly miniaturized data processing unit with capability to operate in autonomous underground mining vehicles. Beyond the state-of-the-art packaging technologies have been developed and the use case solution functionalities demonstrated. The project consortium includes 11 SMEs, 14 LEs and 12 RTOs, and covers the industrial value chain from simulations, sensor development and component packaging, integration and reliability as well as connectivity, cloud and cyber security solutions. The activities go beyond the state of the art, contributing to the competitiveness and leadership of European industry and ECS competences, providing new business opportunities for the partners and their supplier ecosystem. New digitalization capabilities and cybersecurity options for industrial environments have been developed.

Efforts in risk management and re-planning were made for the unforeseen COVID-19 pandemic and global component shortages during the first 24 months. A 9-month extension period had to be planned to meet the planned objectives. The main results include:

UC1 - IOT for digital mining solutions: Air quality & autonomy in mining vehicles Project has produced lot of information on how to build air quality sensing. Testing is lacking due to delays in component delivery. Accurate air quality sensing would enable on demand ventilation and save energy costs, but solutions do not exist. Ventilation is the single biggest operating energy expense in mining operations. Market development on environment sensing technologies has been faster than anticipated at the project start. LIDAR, stereo cameras, image streaming and such technologies outperform the set targets.

UC2 - Condition monitoring of paper mill equipment: The project has enabled capability and knowledge for condition monitoring of paper machines. Sensors (temperature, wear, vibration, oil condition, angle position), hardware configurations applicable for industrial installations, SW for real-time measurement and data collection, capability for local connectivity, and remote configuration.

UC3 - Real-time machining workpiece control system: A linear motion scanning system for simulating the environment (oil and machined chips) has been developed to measure oily parts without the need for cleaning or thermal stabilization. The system strengthens Sylvac position as a technological leader in dimensional metrology.

UC4: Real time monitoring of solar panel manufacturing lines Novel temperature sensors in drying ovens for solar cell manufacturing lines have been developed. This improves process control in PV screen printing: higher uptime, yield, and performance of the final product, savings in paste, utility and operator costs. New opportunities open in high performances solar cells, such as IBC heterojunction, TOPCon, Perovskite.

UC5 - Nuclear plant maintenance and decommissioning: A new in-service inspection robot with advanced robot trajectory planning and a new control user interface has been developed and tested. It enables UJV Rez to improve advanced robotic in-service inspection and maintenance of nuclear power plants.

UC6 - Virtual prototyping professional digital printers: Virtual printer sensors have been developed for evaluating image quality improvements, such as graininess, and color gamut, and for evaluating the print robustness, such as ink wrinkle. The outcome enables CPP to release innovative printer products earlier to the market, increase sales and market share.

Partners have contributed to >130 international conferences, trade shows, workshops and events. 6 peer reviewed open access articles and 8 additional non-open articles are published. 4 patent applications have been filed. New, unforeseen, ideas have been reported by almost all partners. Appx. 200 social media, website and other press releases are published. >60 CHARM LinkedIn posts have been published, and many more by partners.

On component, device and system level, the most important highlights of the CHARM project are:

- Autonomous mine driving simulator completed and released.
- Temperature and pressure sensing in rotating parts developed.
- Wireless Power Transfer (WPT) designed and tested for rotating rolls.
- All Gen2 gas sensor devices - micro-hotplate based sensors, ionic -based sensors for O2 detection, thermal conductivity-based sensors, and optically based CO2 sensors have been developed and tested.
- Wireless vibration sensors have been manufactured and tested/validated.
- Thermo-reflectivity measurements with multiple laser sources used for measurements of moving Si-wafers.
- A semiconductor device with 4 heaters and an array of 9197 Copper pillars for ADPU component embedding has been successfully designed and manufactured.
- Oil monitoring has been demonstrated purpose and updated for detection of metal particles. Successful demonstration at Valmet facilities.
- Virtual Sensor V1 (Image Quality) and Virtual Sensor V2 (Print Robustness) have been finished and exploited for new printer designs.
- IIOT architecture FIWARE Components has been tested in Valmet Jyväskylä The data collection platform based on WP6 architecture has been implemented in Valmet environment.
- Air quality sensors for harsh mining environments have been demonstrated by MCL, IMEC-NL. L-IMIF and E+E.
- A specific test box for the multi-gas sensor system was developed. All sensor devices are mounted, and the setup has been designed and developed to enable performance measurements in well-defined laboratory as well as in harsh conditions.

- SAF Teknika air quality sensors and 3 base stations installed in Sandvik test mine, data collection and sensor readings have been successfully achieved.
- L-IMIF and MCL provided chips for testing in test mine with a focus on shock waves and dust endurability after exposure to blasts in test mine.
- Radar data together with an optical lidar data was being recorded by test drives in Sandvik`s test mine.
- Demonstrator for accurately measuring a machined part with oil and chips on it. Lens with an oleophobic coating coupled to a pneumatic system to reject the oil and chips generated in a machine tool.