

Flux-Minimized Soldering for High-Voltage Automotive Products

The R&D project - **Flux-Minimized Soldering for High-Voltage Automotive Products** - a collaboration between the University of Pannonia and Flex Ltd., with the support of the Hungarian Ministry for Innovation and Technology (ITM), was successfully completed in July, 2026. The \$4.26 million (HUF 1.34 billion) project aimed to enhance the reliability of electronics used in hybrid and autonomous vehicles.

Key Highlights:

- Developed a breakthrough flux-minimized soldering technology for high-voltage automotive electronics.
- Created advanced reliability testing and measurement systems.
- Developed predictive models to better understand and prevent electronic failures.
- Improved cleaning and surface-treatment processes to enhance product quality and durability.

Scope: The primary objective of the research was to improve the reliability of high-voltage electronic systems used in hybrid and autonomous vehicles. The research focused on the investigation of flux residues remaining after the soldering process and their impact on long-term reliability. During the project, the connection between ionic contamination, electromigration, dendrite formation, and leakage currents were studied in detail, and new measurement and testing methodologies were developed for their characterization.

Results: Several innovative measurement and test systems were developed, enabling fast and accurate evaluation of insulation resistance, breakdown voltage, and AC impedance. A multifunctional test panel was designed to support reliability and contamination assessments of various printed circuit board coating systems.

A key achievement was the development of both experimental and computational models for dendrite formation, providing deeper insight into the failure mechanisms of high-voltage electronic systems. Additionally, the optimal process parameters for atmospheric-pressure plasma treatment were identified, resulting in improved solderability and solder joint quality.

As part of the development activities, the dry-ice PCB cleaning technology was enhanced. The upgraded equipment and the newly established process parameter framework enabled more effective removal of soldering residues, particularly for electronic assemblies that previously required cleaning after the assembly process.

A significant outcome of the project is the development of a novel flux-minimized soldering technology and its associated testing methodology.

These advances contribute to increased service life and operational reliability of high-voltage automotive electronic systems. The results of the project can be directly applied to the manufacturing technologies of next-generation electric and autonomous vehicles.

Consortium Partners: University of Pannonia, Flex Ltd.

Funding Authority: Ministry for Innovation and Technology.