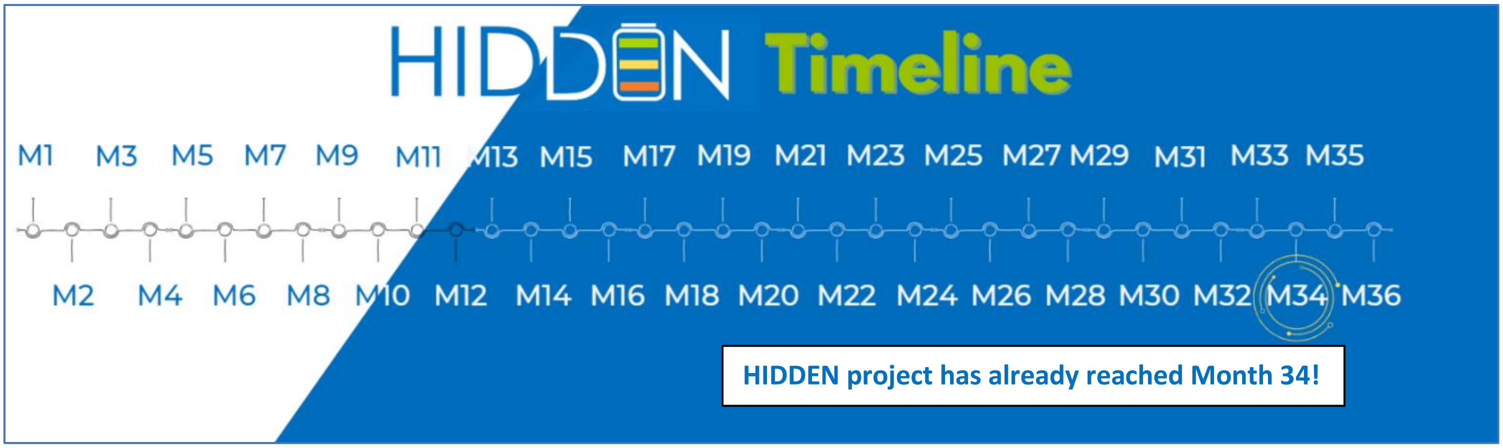

PRESS RELEASE

The project

The HIDDEN project aims to **enhance the lifetime of Li-metal batteries** (LMBs) by 50% and increase the energy density by 50% compared to current Li-ion batteries (LiBs). The project focuses on developing scalable and industry-compatible materials and processes for functional battery layers. To achieve these goals, HIDDEN develops two technologies, innovative self-healing thermotropic liquid crystalline electrolytes (TILCs) and piezoelectric separator technologies to prevent dendrite growth. Advanced electrolyte design is facilitated through multiscale modeling, which accelerates the development of new materials. **Algorithms are employed to monitor dendrite growth**, enabling the assessment of the self-healing methods' effectiveness and triggering self-healing, when necessary, by adjusting the cell temperature. In the first period, the consortium concentrated on developing self-healing methods and materials. In this phase, the consortium tested and validated the technology as well as the production method with tangible results.

The HIDDEN project achievements

The HIDDEN project began by **defining specifications** for the batteries that will be developed throughout the project. In the initial stages, a comprehensive library of model TILCs was created. These TILCs served as the basis for developing processing techniques for the self-healing electrolyte and studying its properties. The generated data from this research, including modeling work was used to guide the subsequent synthesis efforts. Furthermore, materials and layouts for a printed heating element were tested to facilitate on-demand triggering of the self-healing reaction. In addition, **the first piezoelectric separators have been prepared** and their properties and processing methods were tested, evaluated and characterized. To ensure the self-healing methods are activated at the appropriate time, the project team explored **non-invasive methods for detecting dendrite** growth. These detection methods will ultimately be integrated with the **battery management system (BMS)** to enable control over the self-healing process. **HIDDEN-PVDF technology has been tested** and showed very **promising results for the coated PVDF**. Currently, the consortium is focused on finalizing the testing, modifying, and validating the methods for scaling up production.

Advancements on processing of novel self-healing batteries

The design, synthesis and **characterization of two families of TILCs** Thermotropic Liquid crystal (TLC) host matrix+Lithium salts and TILCs-Gen.1 have been completed. Implementation of **Materials-Accelerated Platform (MAP)** discoveries of optimized TILC-Gen.1 and TILC-Gen.2 is still under progress. A pre-polarized PVDF separator to prevent dendrite growth was demonstrated. A List of high-performance additives established to hinder the growth of Li dendrites. Finally, a strategy was formulated for enabling SHEs conceived and relying on the implementation of a MAP-based research methodology.

Processing

Cells were constructed using PVDF and PP/PVDF separators, and the coating process for PVDF separators has been expanded to larger production scales. The coating and impregnation processes for the **self-healing electrolyte (SHE)** were developed on a roll-to-roll pilot scale for the model TILC electrolyte. Successful tests were conducted to facilitate temperature control in the cells, a heating system was built, and a printed heating element on the pouch cell was to reach a temperature of 130 °C.

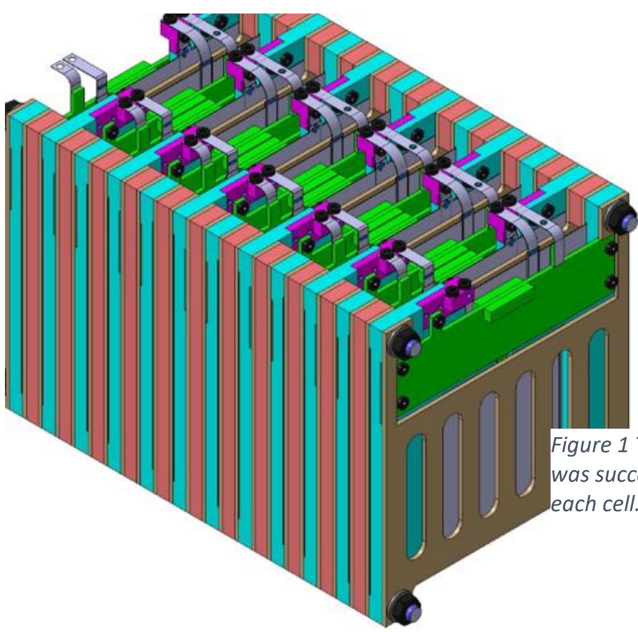

Figure 1 The construction of the cell stack in a 3D configuration was successfully achieved, with one BMS Slave assigned to each cell.

A heating element made of transfer metal foil is under integration into the **Battery Management System (BMS)** and it stills to be tested with complete cells. Hardware for measuring the resistance of single electrode sheets and bi-cell resistance was developed, but the measurement approach still requires validation.

TESTING

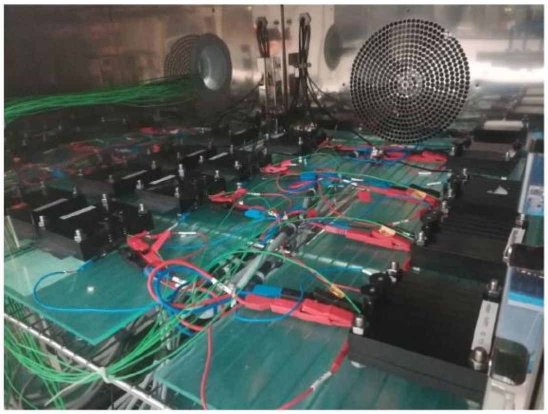

Figure 2 Cells arrangement inside temperature chamber

HIDDEN PVDF technology was compared to a reference LMB and the analysis demonstrated that PVDF offers several advantages over the reference LMB. Specifically, **PVDF coated cells showed enhanced durability** with an 8.3% increase in cycling at the same state of health (SoH) of 80%. They also showcased improved stability, as the variability in SoH values decreased from 14% to 4% at the same cycle number (cycle #60). Additionally, PVDF-c cells demonstrated the ability to inhibit the rapid accumulation of dead lithium, delaying it by 20 cycles over an average lifespan of 60 cycles.

Analysis

Regarding the development of a non-invasive analysis tool for detecting dendrite growth, the tool demonstrated a 60% accuracy in detecting inactive lithium. The development of the Battery Management System (BMS) is ongoing, which will include typical BMS functions such as voltage, current, and temperature monitoring. Additionally, a physics-based modeling workflow spanning from atomistic to microstructural scales has been successfully demonstrated and can be leveraged for further advancements. Deep graph neural network architectures have been introduced and tested as a basis for the HIDDEN MAP solution. The work continues by incorporating high-throughput synthetic data and integrating it with experimental results.

More information: www.hidden-project.eu

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