PRESS RELEASE

HIDDEN project is already halfway through its duration and had the mid-term review meeting on the 24th of May 2022 presenting the excellent project achievements with great success!

The project

The HIDDEN project develops self-healing methods to enhance the lifetime of Li-metal batteries (LMBs) by 50%, and to increase the energy density of batteries 50% above the current level achievable with current Li-ion batteries (LiBs). The materials and their processes for functional battery layers are targeted to be scalable and industry compatible. To achieve these goals, HIDDEN develops novel self-healing thermotropic liquid crystalline electrolytes (TILCs) and piezoelectric separator technologies to prevent dendrite growth. The consortium applies multiscale modelling for advanced electrolyte design to speed up the development of new materials. Dendrite growth is monitored with algorithms, which allows following effects of the selected self-healing methods and triggering the self-healing at a correct time by increasing the cell temperature. During the first period, the consortium has focused on developing the self-healing methods and materials. During the second period, the consortium will test, modify, and validate the methods, and scale-up the production.

Project achievements

The HIDDEN project started by defining specifications for the batteries that will be developed during the project. As first steps, we have also developed a library of model TILCs, which has been used for developing processing methods for the self-healing electrolyte, as well as to study its properties to generate data e.g. for the modelling work, which will guide the next steps in the synthesis work. We have also tested materials and layouts for a printed heating element, which will be used to trigger the self-healing reaction on demand. In addition, the first piezoelectric separators have been prepared and their properties and processing methods are currently under investigation. In order to trigger the self-healing methods at the right time, we have also studied non-invasive methods to detect the dendrite growth, which will be finally integrated with the battery management system (BMs) to control the self-healing.

Advancements on processing of novel self-healing batteries

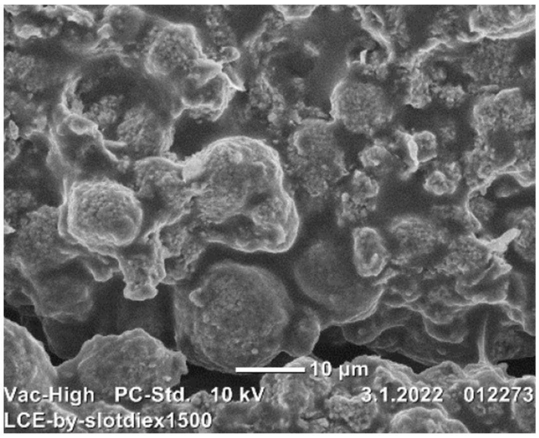
One of the topics where we have recently focused on is processing of the novel self-healing batteries (SHBs). The TILCs and the piezoelectric separator require special processing methods, as the standard Li-ion manufacturing processes are not optimal as such for the HIDDEN materials. Our goal is to be able to manufacture SHBs in a way, which is scalable and

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957202.

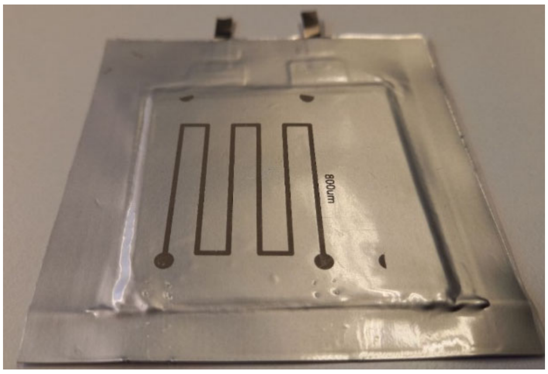
safe, and which does not require too complicated processing steps. This would enable adoption of the self-healing functionalities in commercial cells in future. The results look promising so far, as we have been able to coat our model TILC on top of the NMC electrode and infiltrate it into the cathode as well. We are now proceeding from coin cell test to pouch cells, which requires also good practices for cutting of the electrodes. Laser cutting of the combined NMC and solid electrolyte layer, as well as the Li metal anode, seems to be working for these materials. Regarding the piezoelectric separator, we have found ways to control the porosity of the layer and upscaling of the coating process is planned.

Achievements on the Thermotropic Liquid Crystals

Thermotropic Liquid Crystals (TLCs) are fluid-like but ordered self-assemblies under a certain temperature range. Usually, liquid crystals are not inherently ionically conducting. If used as an electrolyte, TLCs need to be engineered to encode ionic transport features to generate Thermotropic Ionic Liquid Crystals (TILCs). TILCs have been shown to assist dimensionality-controlled (1D/2D/3D) Li^+ transport and lead to smooth Li deposition onto the Li-metal anode, preventing dendrite formation. HIDDEN used this innovative approach as a starting point and developed it a step further by synthesizing a series of model TILCs. These TILC-Gen^1 have been used to develop a scalable process to coat the electrolyte on/in the cathode, and to generate data for modelling. The first laser cutting tests with cathode-TILC composites are also done. Next, novel TILCs with different (i.e. fine-adjusted) chemical structures were synthetized: TILC-Gen^2 materials. The first TILC-Gen^2 electrolytes have been designed, synthesized, and evaluated, and the data will be used to design TILCs with optimal performances. We have also developed a printed heating element, aimed to trigger on demand self-healing.



Cross sectional image of electrode with liquid crystal electrolyte



A photo of the screen-printed heating element on the pouch cell

Piezoelectric separator successfully tested

The piezoelectric effect is the ability of certain materials to accumulate electric charge in response to a mechanical stress. HIDDEN will use this phenomenon in a separator. When growing dendrites will eventually reach the separator, it will bend, and generate a local electric field. This will guide the Li^+ cations to deposit smoothly between the growing

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957202.

dendrites, and not on top of them, increasing the cell cycle life. HIDDEN has tried two methods for enabling piezoelectric separator – casting a porous self-standing poly(vinylidene fluoride) (PVDF) separator, and coating the porous PVDF layer on a commercial polypropylene (PP) separator. Both were successful, but the later cannot be efficiently poled with an external field. So, the porous PVDF separator is taken forward for battery cycling.

Cell characterization techniques tested with outstanding results

Several cell characterization techniques were screened out and some selected to be suitable for detecting dendrite growth. The validation results show that specific parameters allow detecting degradation in the tested LMBs. The tested detection techniques can be implemented in embedded systems to sense degradation, activate self-healing methods, and assess the overall benefits. Some techniques are easier than others, but in general all the non-invasive techniques proposed can be implemented in BMSs, except (till date) for coulombic efficiency.

The midterm review meeting

Took place online on the 24th of May 2022 with the participation of all consortium partners. The meeting started with a presentation of the Battery 2030+ project delivered by Prof. Kristina Edström, emphasizing the great added value that HIDDEN brought to this initiative. Afterwards, Work Package (WP) leaders presented the progresses in their respective WP while the Project Officer and three external reviewers addressed their questions and comments. The excellent progress achieved so far was acknowledged and interesting discussions took place about the potential technological solutions as well as on protection of the generated intellectual property.

The HIDDEN project will increase the quality, reliability and lifetime of Li-metal batteries, paving the way for electrification of transportation. In addition, we expect to generate industrial opportunities for the next generation battery industry in Europe.

More information: www.hidden-project.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957202.