DEVELOPMENT OF 3D-METALLIC NANOSTRUCTURED AND LITHIOPHILIC CURRENT COLLECTOR FOR NEXT GENERATION OF LI-ION BATTERIES

A.Chbani (achbani@leitat.org)1, A. Escamilla[1], M. Madinehei[1], C. Aucher[1]
[1]Leitat Technological Center, Circular Economy & Descarbonization unit, Energy Storage Group, Terrassa, Spain

Introducction

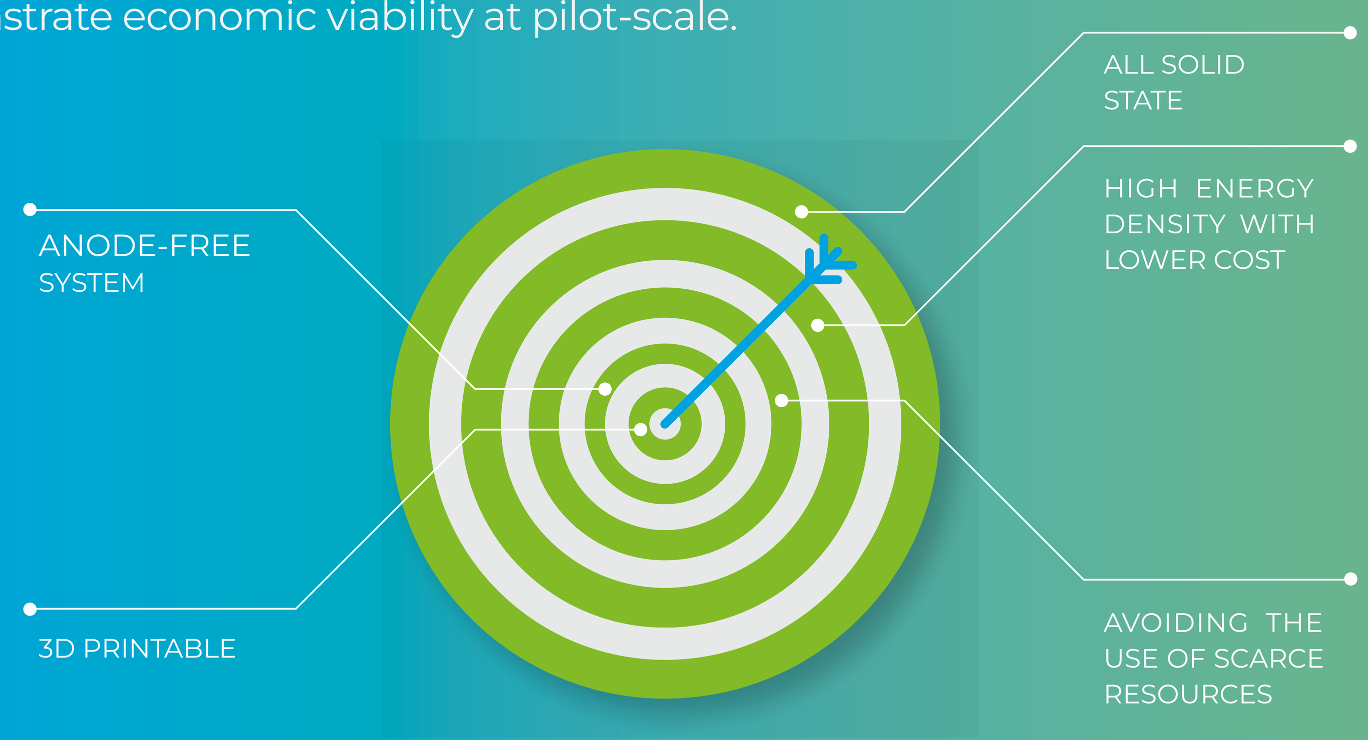
All solid-state batteries (ASSBs) are being considered as promising candidate for next generation Li-ion batteries due to their extraordinary energy density, long life cycle and great safety. However, there are several drawbacks that limit their performance such as the high internal resistance at solid electrodes/electrolyte interfaces and the accumulation of electrode material (dendrites). The main solutions are to improve the electrolyte or membrane, but also to modify and prepare new anodes able to improve the electrode/electrolyte interface.

Lithiophilic current collector are promising candidates for ASSBs due to:
- High surface area (3D nanostructure)
- Low cost and good mechanical properties
- Long life cycle

In this work, lithiophilic current collector-based anode-less concept have been investigated and compared with pristine current collector and Li metallic as anode, showing Ag-Cu and Sn-Cu anode promising results for Li-ion batteries.

Objectives

- Develop an anode-free solid-state batteries with high energy density.
- Manufacture the batteries by a cost-competitive and sustainable VAT photopolymerization 3D printing.
- Demonstrate economic viability at pilot-scale.



Lithiophilic current collector

The lithiophilic current collector-based anode-less concept consists of layer formation (e.g., metallic layer) via electroplating or electroless on current collector as Cu foil. After that treatment, a pre-lithiation, via electrochemical or physico-chemical techniques, is done to "activate" the electrode for its use in a battery.

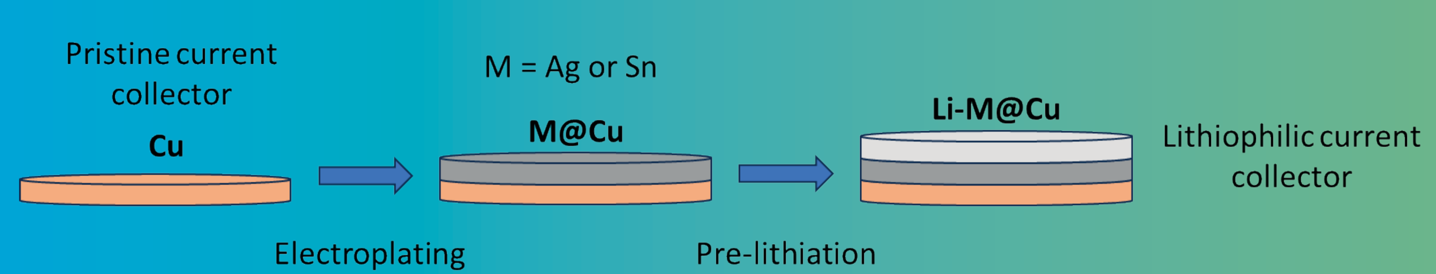


Figure 1. Schematic illustration of lithiophilic current collector preparation

Results

The development of the lithiophilic current collector was carried out in collaboration with MKS ATOTECH® which provided the electrolytic baths for electroplating. Two different types of metals (Ag or Sn) were electrochemically deposited on a Cu current collector. Then, they were electrochemically and physically characterized : Stripping plating vs Li metallic, charge-discharge in full cell and SEM characterisation.

For the SEM results, both samples have a 3D structure, but the homogeneity of these layers is different, with the Sn layer showing a better homogeneity.

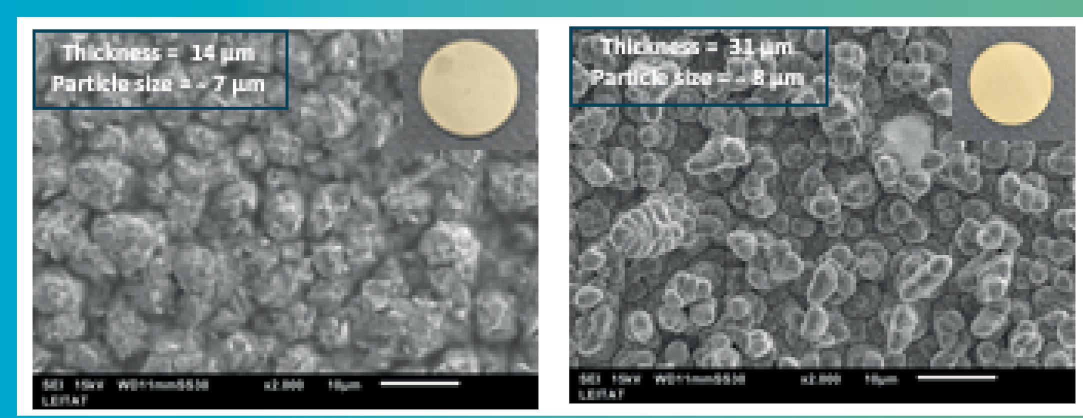


Figure 2. SEM image of Sn@Cu sample (left) and Ag@Cu (right) after electrodeposition

For the stripping plating, the results show the cyclability has been improved by around 50% compared to the pristine current collector (i.e., Cu foil 400 cycles vs Ag@Cu 600 cycles). This improvement is due to the intercalation of Li on the cathode and conversion of Li on the anode. For the charge-discharge in full cell, the capacity is around 30% less than the expected battery capacity. The proposed solution for this decreasing of the capacity is pre-lithiation of anode before assembling.

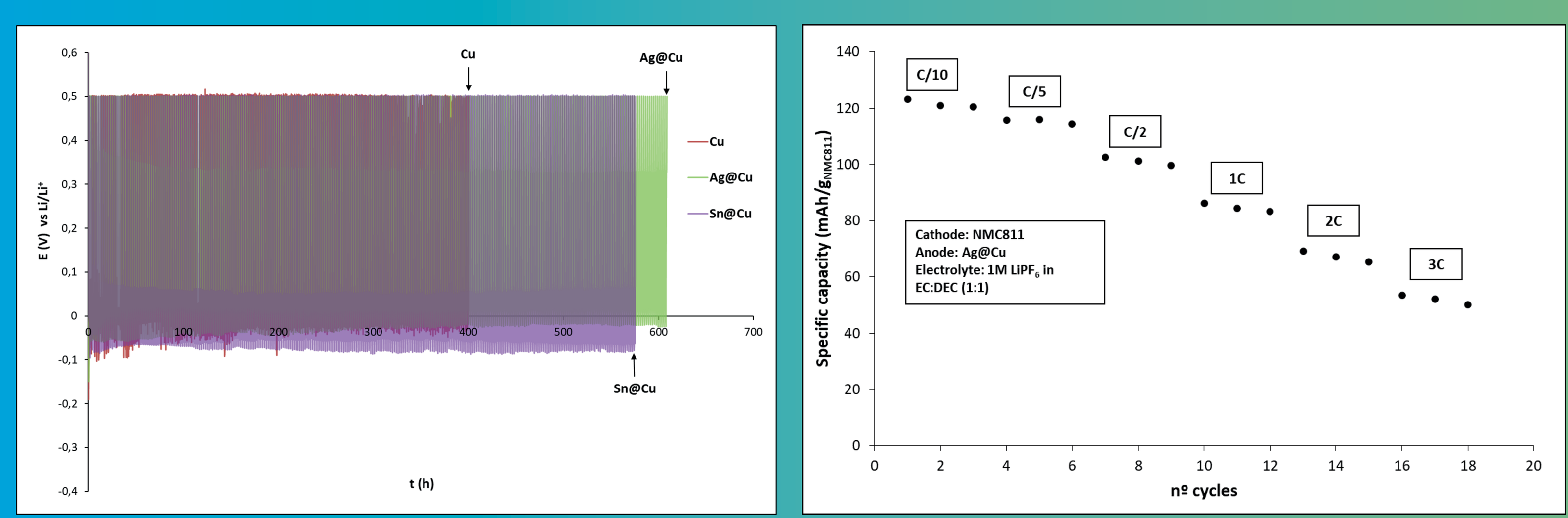


Figure 3. Stripping plating of Cu and lithiophilic current collector vs Li metallic at 0.4 mA-cm-2 (left) and C-rate of Li-Ag@Cu electrode vs NMC811 in full cell (right)

Conclusions

The lithiophilic current collector based on Sn and Ag have shown:
a 3D- nanostructure with high surface area for the Li deposition higher stability in the long cycle versus Li (intercalation and deintercalation) than pristine current collector lower capacity than conventional Li-ion battery (possible solution; pre-lithiation).

Consortium

The AM4BAT consortium composed of 4 SMEs, 3 RTOs, 2 universities and 2 large industries brings the necessary expertise to cover the development of such novel battery, from the synthesis of the materials, their modification, formulation and up-scaling, until the component printing and the cell assembly.

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