



**Avviso di Lecture:**

**“Most recent advances at HIU towards environmentally-friendly and safer lithium batteries ”**

*Prof. Stefano Passerini  
Helmholtz Institute Ulm (HIU)  
stefano.passerini@kit.edu*

**Casaccia, 19 febbraio 2019  
ore 10:30 - Sala Mimose**



Italian National Agency for New Technologies,  
Energy and Sustainable Economic Development

**Dipartimento Sostenibilità dei  
Sistemi Produttivi e Territoriali  
Divisione Tecnologie e Processi dei  
Materiali per la Sostenibilità**



## ABSTRACT

The continuously increasing importance of lithium-ion batteries for small-, medium-, and large-scale applications, ranging from mobile phones and laptops to electric vehicles and stationary energy storage, has triggered an increasing awareness concerning their environmental impact and safety [1,2].

With regards to the environmental issue, the utilization of water-soluble binding agents as, for instance, sodium carboxymethyl cellulose (CMC) for graphite anodes has led to a substantial improvement in terms of cycling stability and first cycle coulombic efficiency [3]. For the cathode side, however, the pronounced sensitivity of any kind of lithium transition metal oxide (e.g.,  $\text{LiNi}_{0.5}\text{Mn}_{1.5}\text{O}_4$  (LNMO),  $\text{Li}[\text{Ni}_{1/3}\text{Mn}_{1/3}\text{Co}_{1/3}]\text{O}_2$  (NMC), or  $\text{Li}_2\text{MnO}_3$ \*NMC) towards water in combination with the resulting severe pitting corrosion of the aluminum current collector has so far prevented the implementation of aqueous binders and processing techniques [4,5]. Herein, we will show that these issues can be overcome when introducing new complementary strategies, resulting in lithium-ion cathodes offering enhanced cycling stability, improved rate performance, and overall higher specific capacities [6-8].

With respect to safety, all-solid-state batteries (ASSBs) promise increased energy densities by enabling the safe use of lithium metal anode. Owing to their good ionic conductivity at room temperature, high ductility and low density, sulfidic electrolytes are among the most attractive candidates for high-energy ASSBs. Herewith, we report two different, but potentially complementary, approaches for the development of bulk-type ASSBs based on sulfidic solid electrolytes.

Firstly, we discuss the importance of materials selection to achieve high active material utilization with practical electrode loadings. As an example, the Li-S system is chosen for its particularly challenging, sluggish, cathode kinetics. We demonstrate how composite cathodes incorporating transition metal sulphides (such as, e.g.,  $\text{FeS}_2$ ) can improve sulphur utilization providing stable areal capacities [9].

Further, an easily scalable production procedure taking advantage of the ductility of sulfidic electrolytes is discussed. The tape casting procedure herein developed allows to easily process a slurry-based composite cathode ( $\text{LiNi}_{0.6}\text{Mn}_{0.2}\text{Co}_{0.2}\text{O}_2$ ) by means of binder and solvent compatibles with the  $\beta\text{-Li}_3\text{PS}_4$  electrolyte [10].

### References:

- [1] D. Bresser et al., *Energy Environ. Sci.* 11 (2018) 3096-3127.
- [2] J. Kalhoff et al., *ChemSusChem* 8 (2015) 2154-2175.
- [3] H. Buqa et al., *J. Power Sources*. 161 (2006) 617-622.
- [4] M.M. Thackeray, *J. Am. Ceram. Soc.* 82 (1999) 3347-3354.
- [5] X. Zhang et al., *J. Power Sources*. 196 (2011) 5102-5108.
- [6] N. Loeffler et al., *ChemSusChem*. 9 (2016) 1112-1117.
- [7] N. Loeffler, et al., *J. Power Sources*. 248 (2014) 915-922.
- [8] M. Kuenzel et al., *ChemSusChem* 11 (2018) 562 - 573.
- [9] U. Ulissi et al., *Adv. Energy Mater.* (2018) 1801462.
- [10] T. Ates et al., *Energy Storage Materials*, (2018) 10.1016/j.ensm.2018.11.011.



Italian National Agency for New Technologies,  
Energy and Sustainable Economic Development

**Dipartimento Sostenibilità dei  
Sistemi Produttivi e Territoriali  
Divisione Tecnologie e processi dei  
materiali per la sostenibilità**



## **Prof. Stefano Passerini**

Stefano Passerini is Professor at the Karlsruhe Institute of Technology since January 1, 2014 and Director of the Helmholtz Institute Ulm since October 2018. His research activities are focused on electrochemical energy storage in batteries and supercapacitors. Co-author of more than 500 scientific papers (Scopus H-Index: 74), a few book chapters and several international patents, he has been awarded in 2012 the Research Award of the Electrochemical Society Battery Division. Since 2015 he has been appointed as Editor-in-Chief of the Journal of Power Sources.

