GRadient- and multi-matErial procEssing of Next-generation solid-state-BATteries using direct material processing

GREEN-BAT

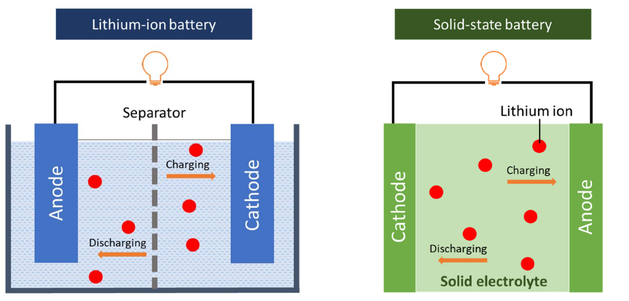
Vinay Gidla[1], Arman Hasani[1], Chinmayee Nayak[1], Vasanth Gopal[2], Behnam Chameh[3], Vesa-Pekka Lehto[3], Josh Thomas[4], Henrik Eriksson[4], Mirko Riede[5], Franz Marquardt[5], Shrikant Joshi[2], Ashish Ganvir[1*]

[1] University of Turku, Turku, Finland [2] University West, Trollhättan, Sweden [3]University of Eastern Finland, Kuopio, Finland

[4] LiFeSiZE (LZ), Uppsala, Sweden [5] Fraunhofer IWS, Dresden, Germany

Tackling the challenges of All Solid-State Battery (ASSB) manufacturing with our innovative manufacturing approach

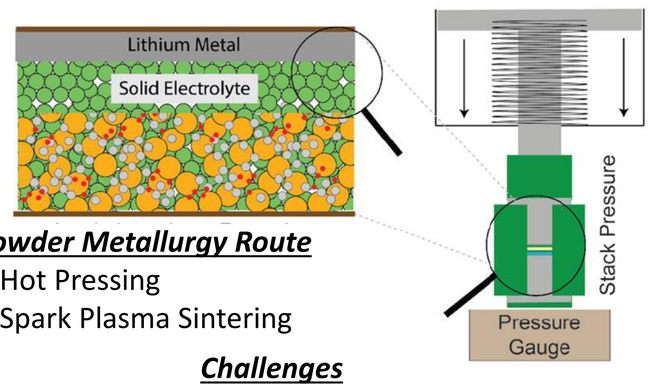
Background



Solid state batteries over Lithium Ion Batteries

- High energy density
- Enhanced Safety
- More efficient energy storage system
- Can withstand higher temperatures

Manufacturing Challenge



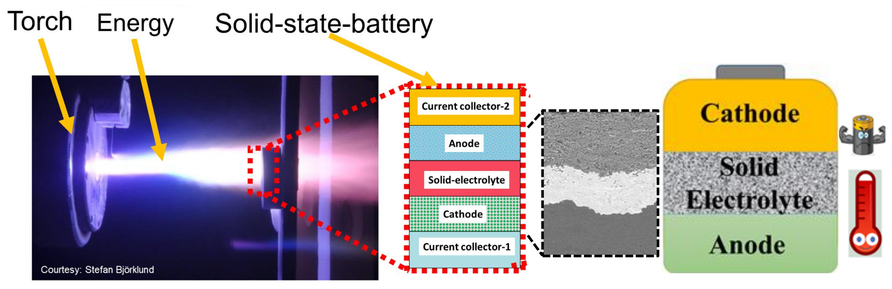
Powder Metallurgy Route

- Hot Pressing
- Spark Plasma Sintering

Challenges

- Poor contact
- Multi step process
- Low production rate
- Size and shape limitation

Proposed Solution

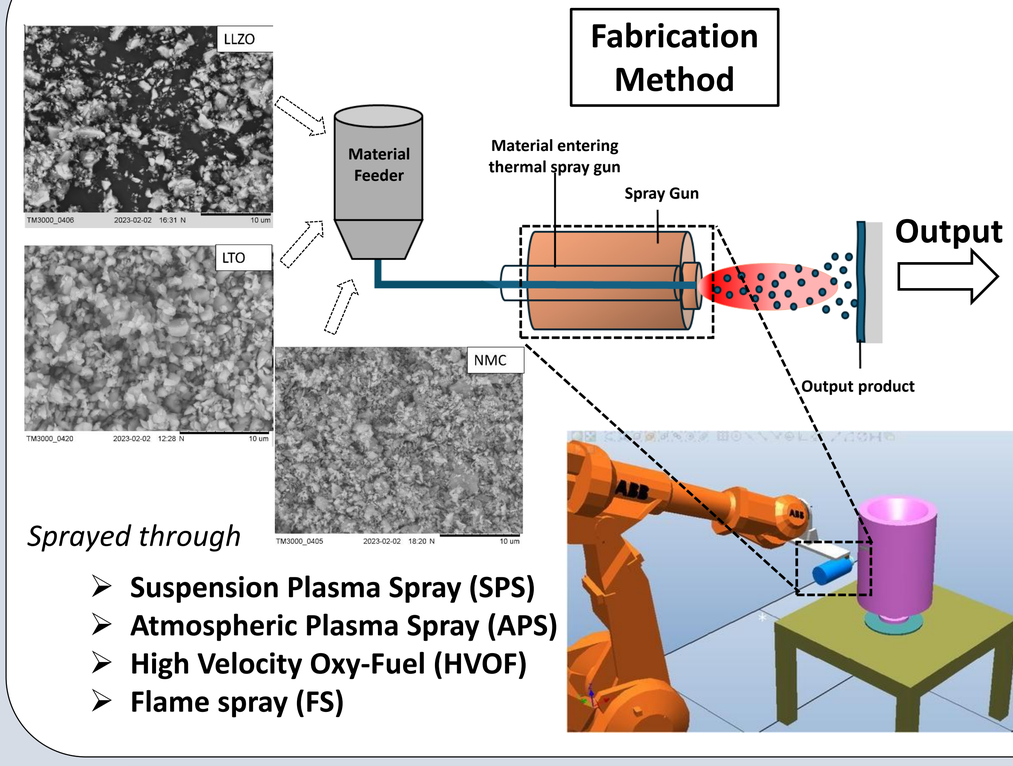


Deposition of all cell constituents in single step using thermal spray process

- High production rate
- Excellent contact between electrodes
- No limitation on size and shape

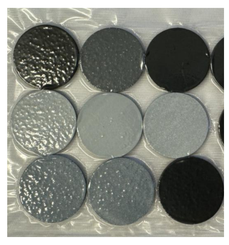
Successfully fabricated individual ASSB constituents (anode, cathode and solid-electrolyte (SE)), half cell and full cell

Fabrication Method

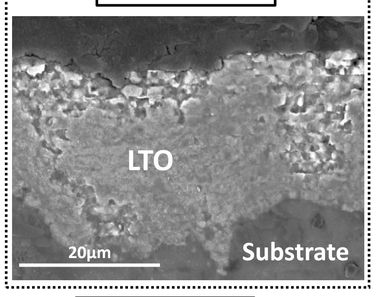


Sprayed through

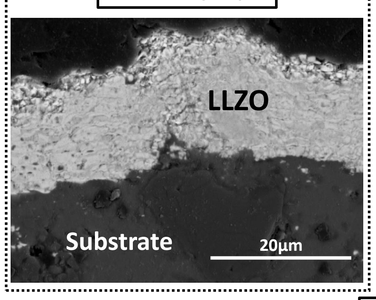
- **Suspension Plasma Spray (SPS)**
- **Atmospheric Plasma Spray (APS)**
- **High Velocity Oxy-Fuel (HVOF)**
- **Flame spray (FS)**



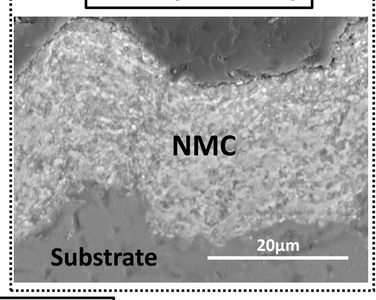
LTO (Anode)



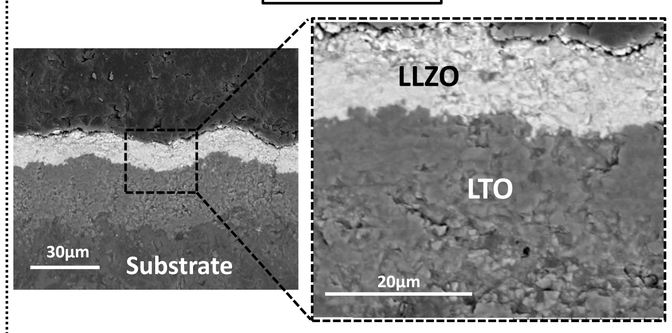
LLZO (SE)



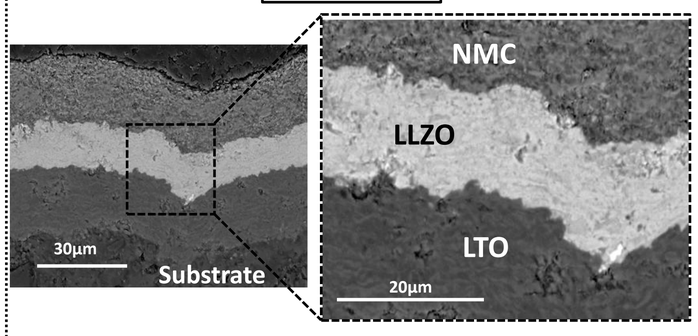
NMC (Cathode)



Half cell

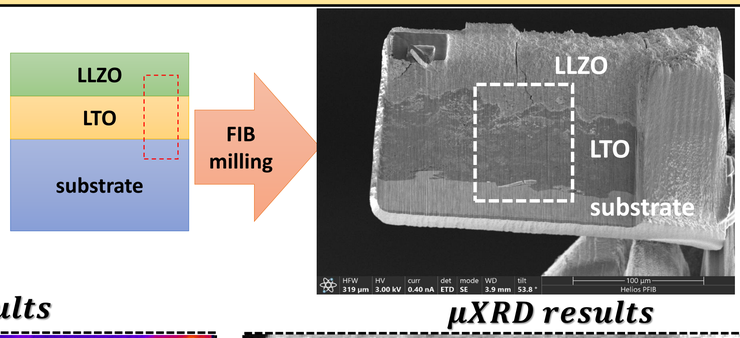


Full cell

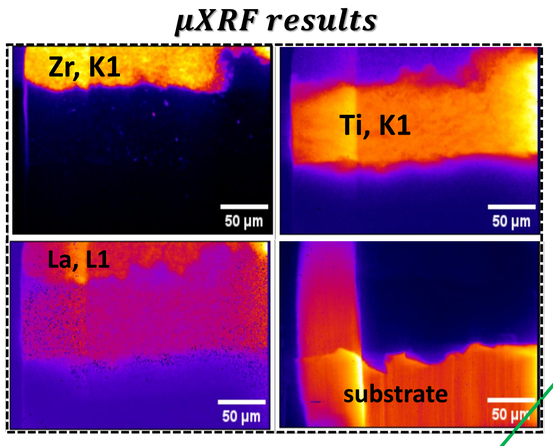


Solid-Solid Interfacial Analysis for optimization and gaining in-depth insights into electrode interface behavior

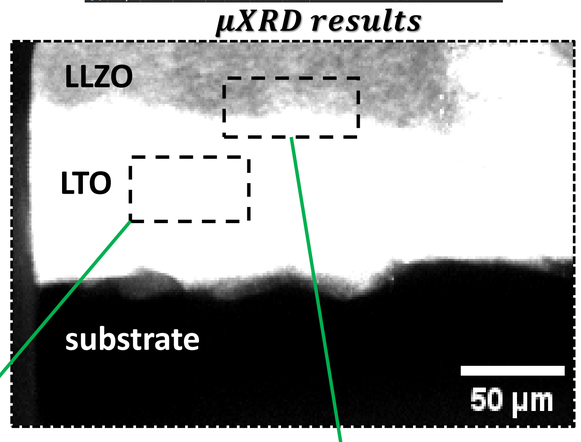
Synchrotron studies for Electrode interface analsyis through μXRD and μXRF

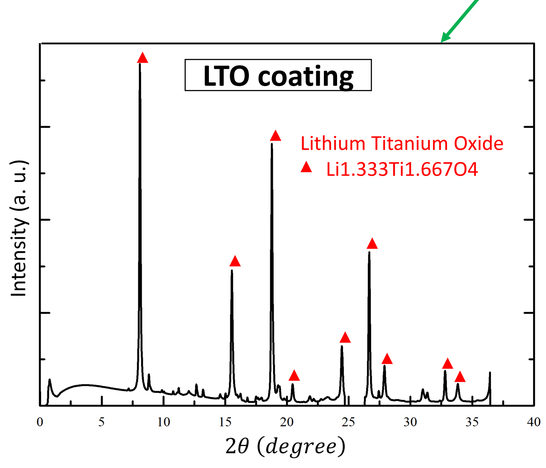


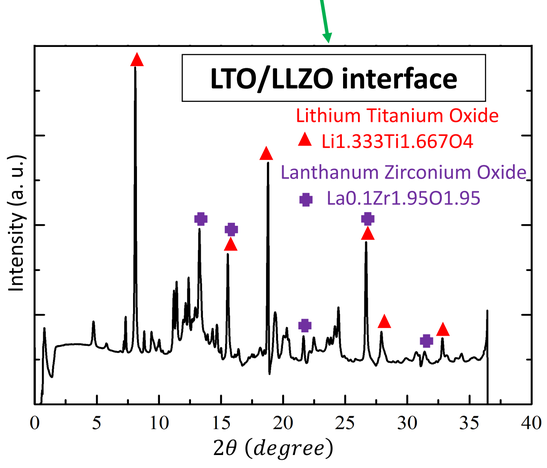
μXRF results



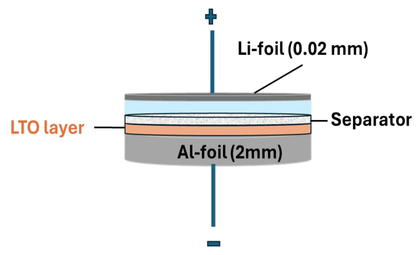
μXRD results

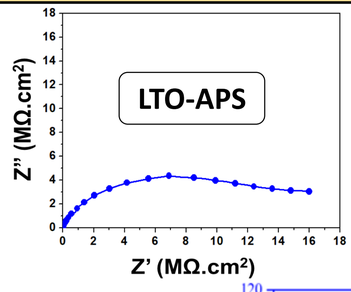


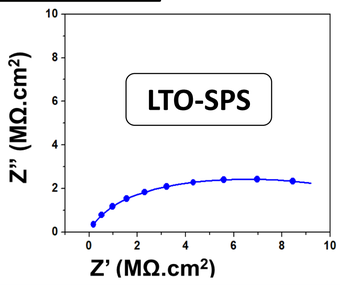


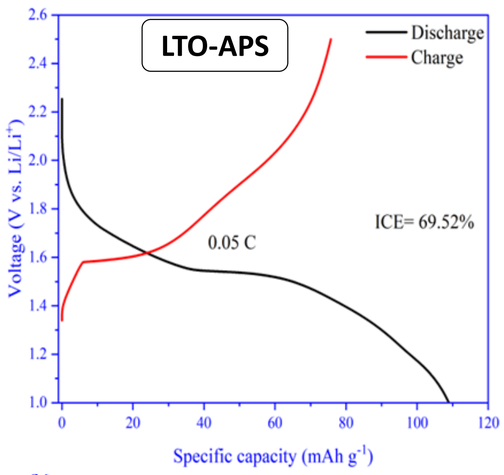


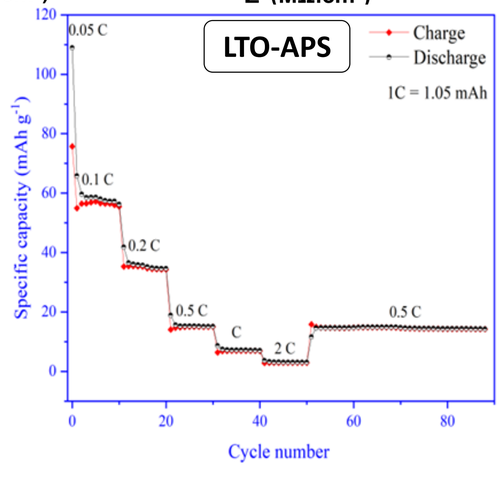
Battery Performance of our fabricated cells in action!

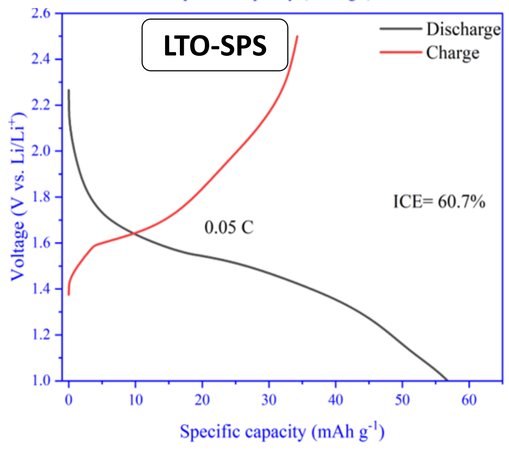


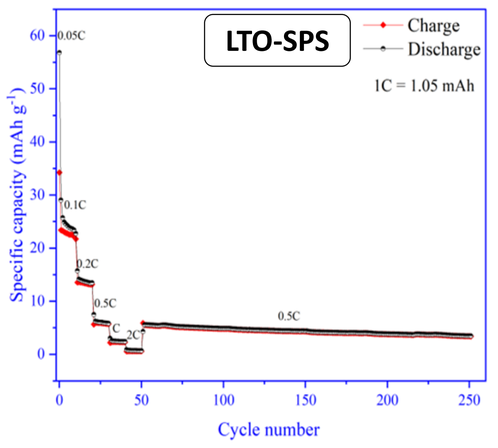












Key Takeaways

◇ **Revolutionizing Battery Fabrication** – Thermal spray enables rapid production of single electrodes, half-cells, and full cells for ASSLBs, breaking barriers in size, shape, and complex multi-step processes.

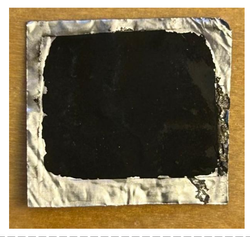
◇ **Breakthrough Insights from Synchrotron μXRD** – Optimizing heat input during deposition minimizes unwanted phase changes, ensuring better material stability.

◇ **Proven Performance** – Battery tests confirm that, with the right optimization, thermal spray is a game-changer for scalable ASSLB manufacturing.

Next Step

LTO

LFP



The initial trial on depositing battery materials on Al foil sprayed through Low Power Plasma Spray

Contact

Prof. Ashish Ganvir
ashish.ganvir@utu.fi
+358(0)504782729

Acknowledgement

M-ERA.NET
Research Council of Finland
SMWK Wissenschaft Sachsen. Exzellente Wissenschaft. Aus Tradition.
VINNOVA Sweden's Innovation Agency