

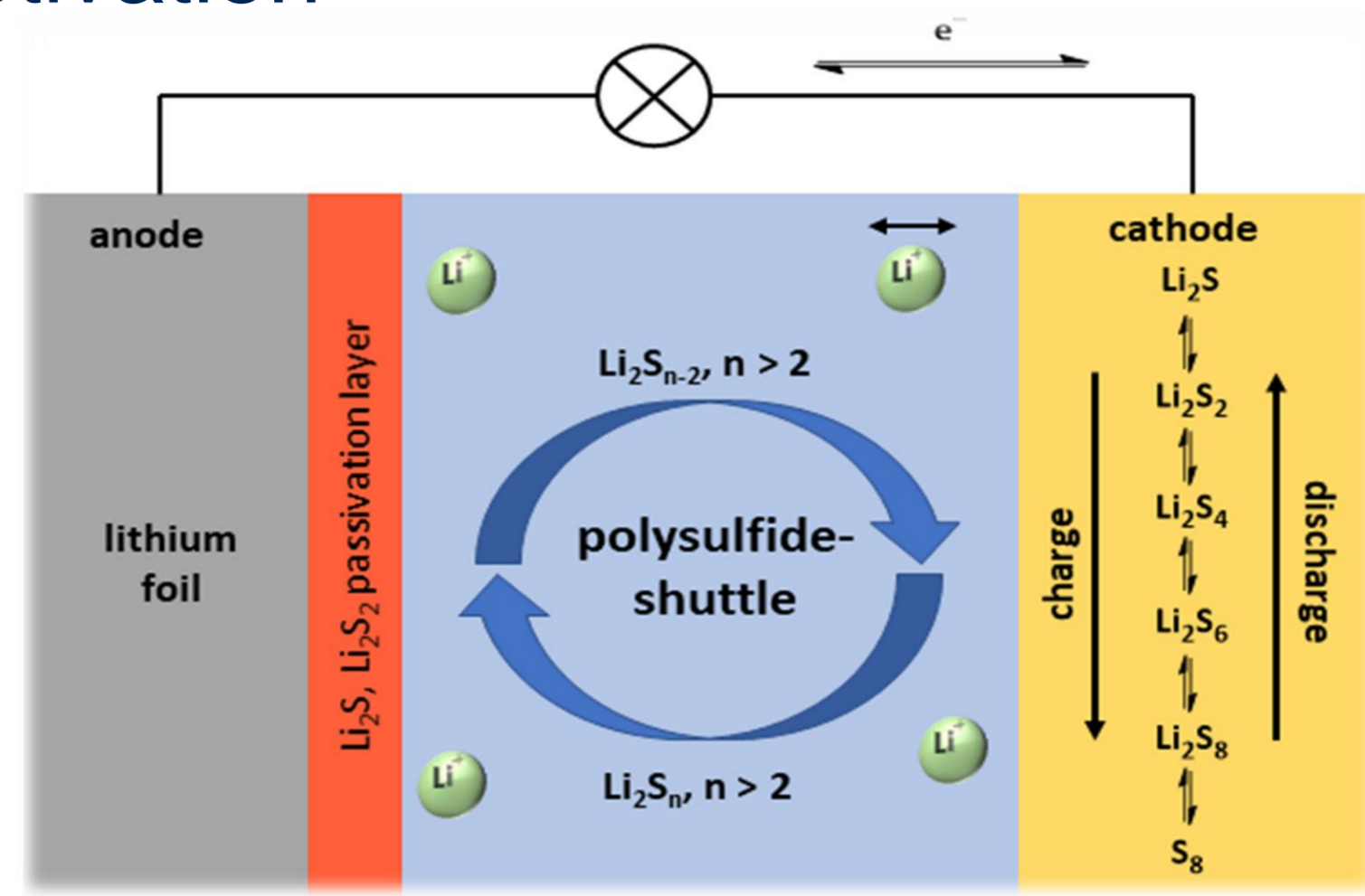
Generation of innovative $\text{Li}_2\text{S}@C$ active materials via plasma processes

Levien, M.¹, Hirt, S.², Sous, P.², Wennig, S.², Oberschachtsiek, B.², Kruth, A.¹

¹Leibniz Institute for Plasma Science and Technology (INP) / Felix-Hausdorff-Straße 2 / 17489 Greifswald, Germany

²The hydrogen and fuel cell center (ZBT GmbH), Carl-Benz-Straße 201, 47057 Duisburg, Germany

Motivation

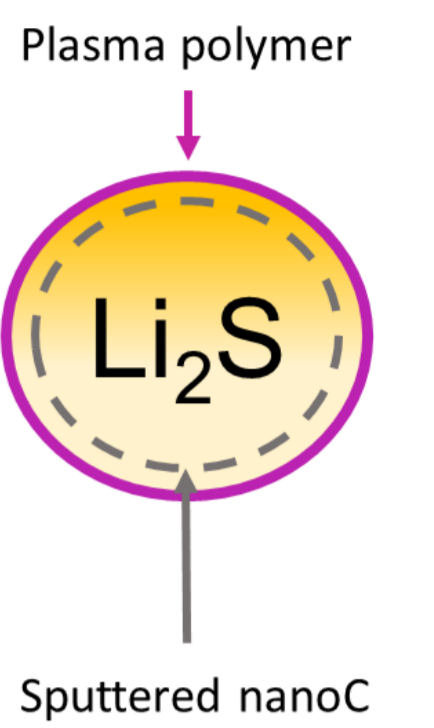


Working mechanism of a lithium-sulfur battery including the polysulfide shuttle [1, 2].

- High theoretical capacity and energy density
- No pollutant or expensive active materials
- Suffer from low capacity retention and low high rate capability
 - Low electric and ionic conductivity
 - Polysulfide shuttle mechanism

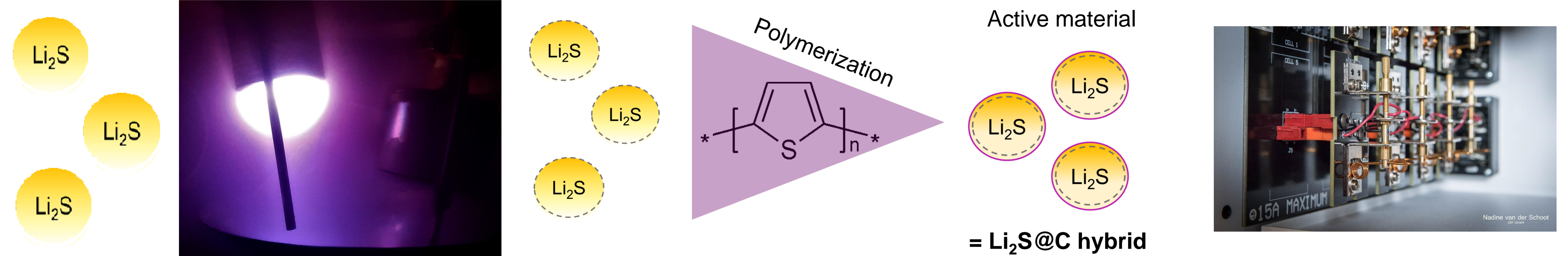
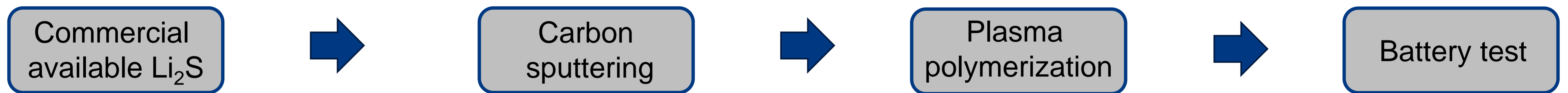
Approach

- Sputtering of nano-sized carbon on Li_2S
- Encapsulation of Li_2S with electrical conducting plasma polymer



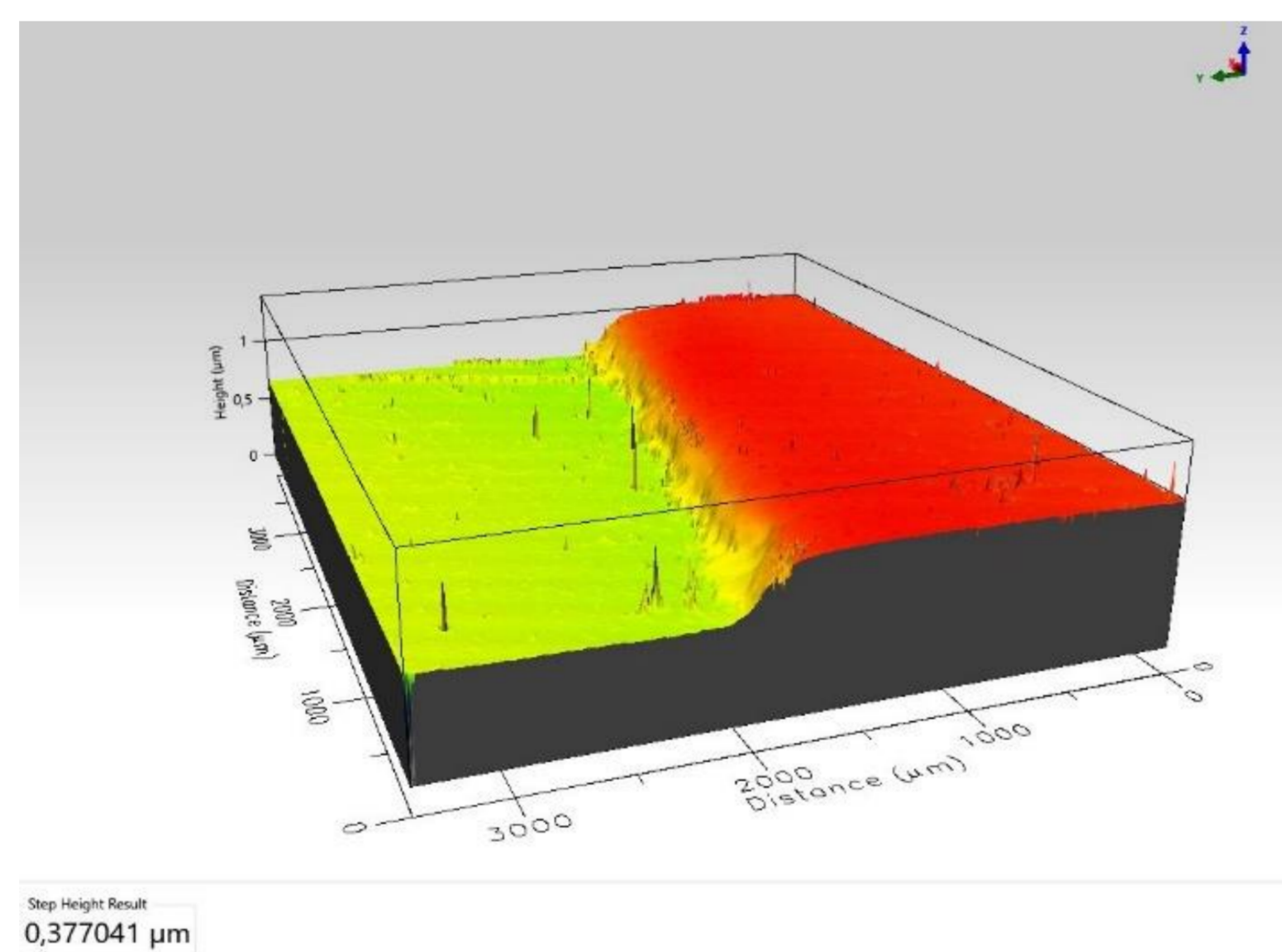
- Enhancing electrical conductivity
- Reducing the polysulfide shuttle

Process

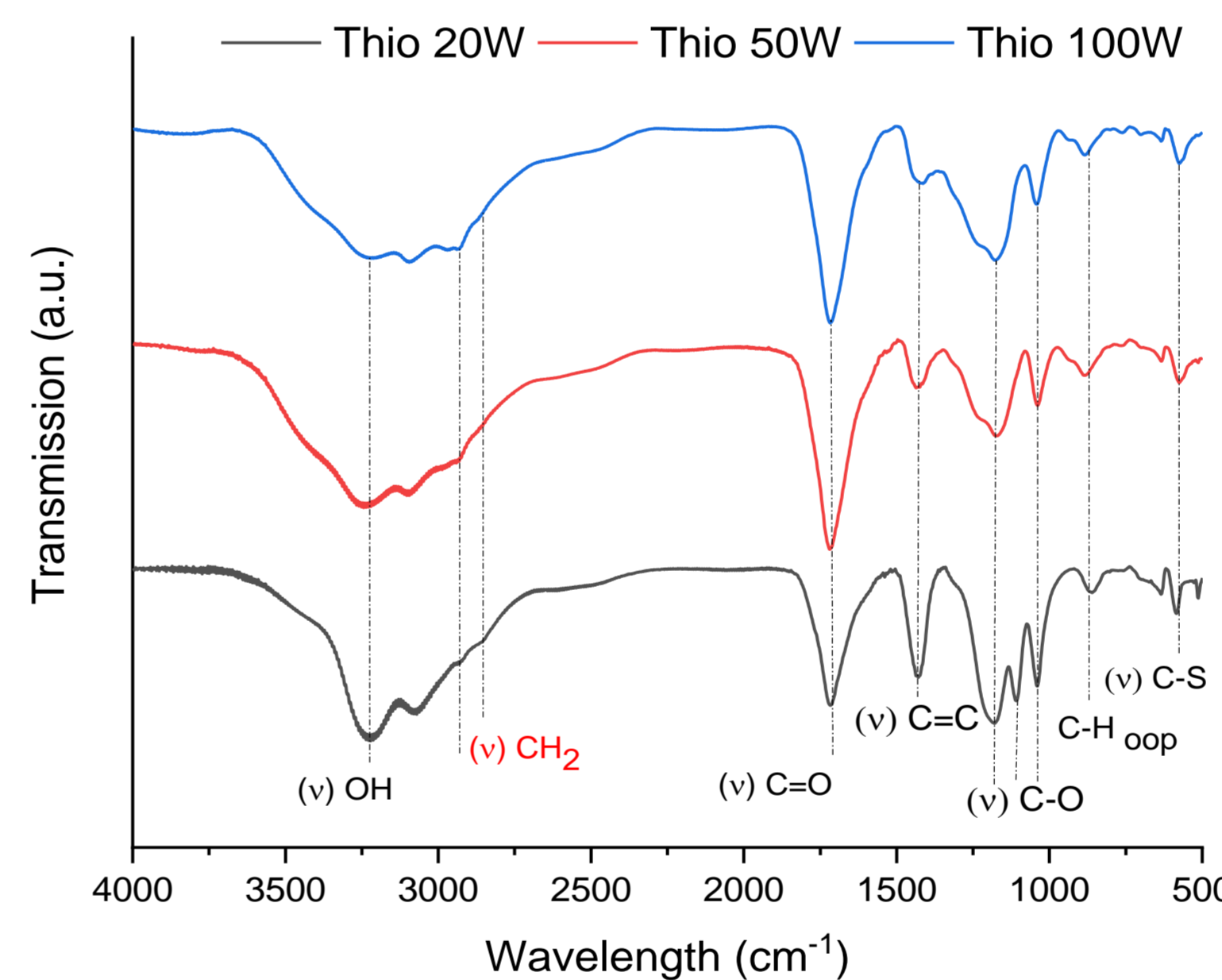


Results

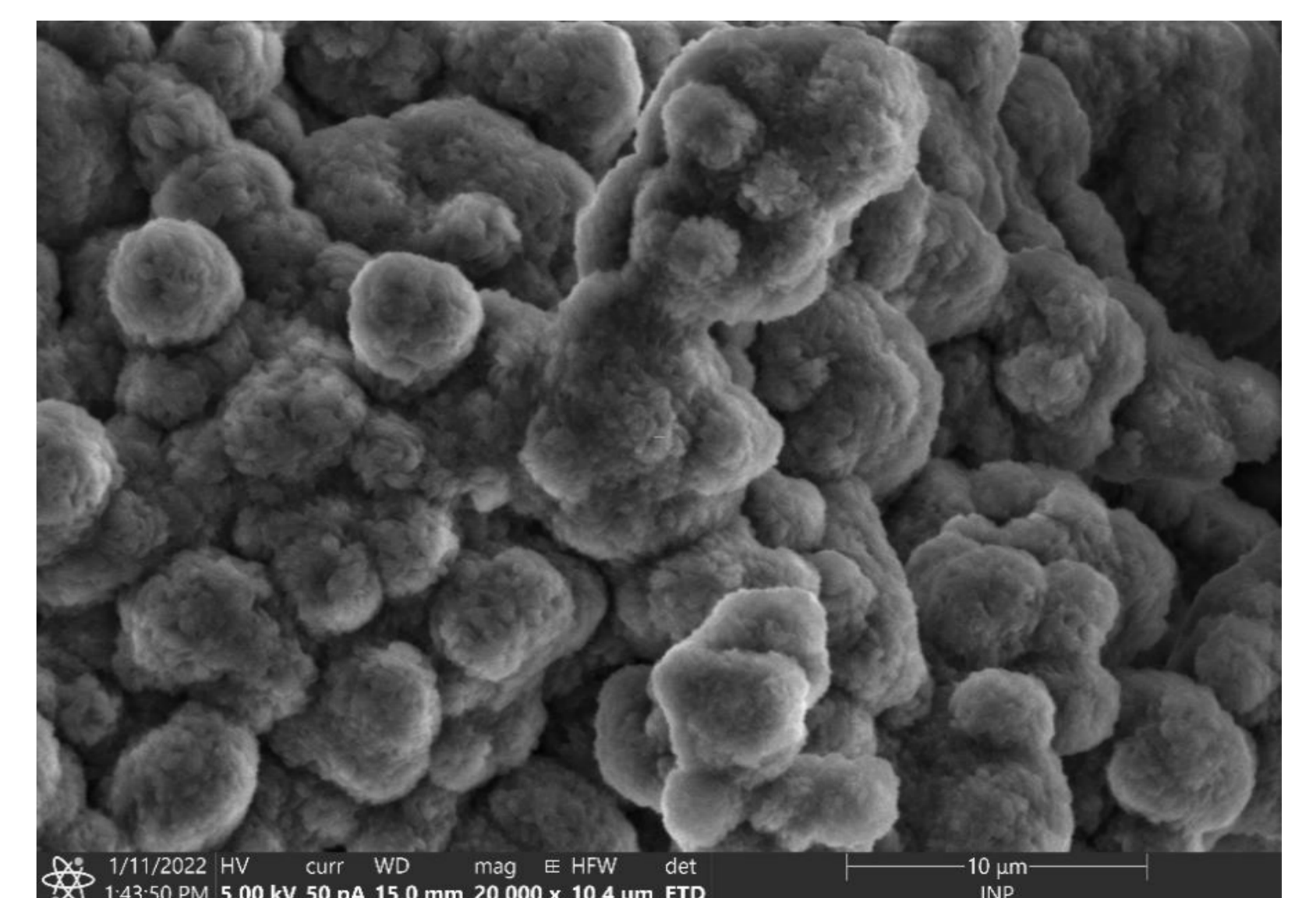
Structural characterization



- Polymer layer thickness from 100 nm to 500 nm depending on process parameters

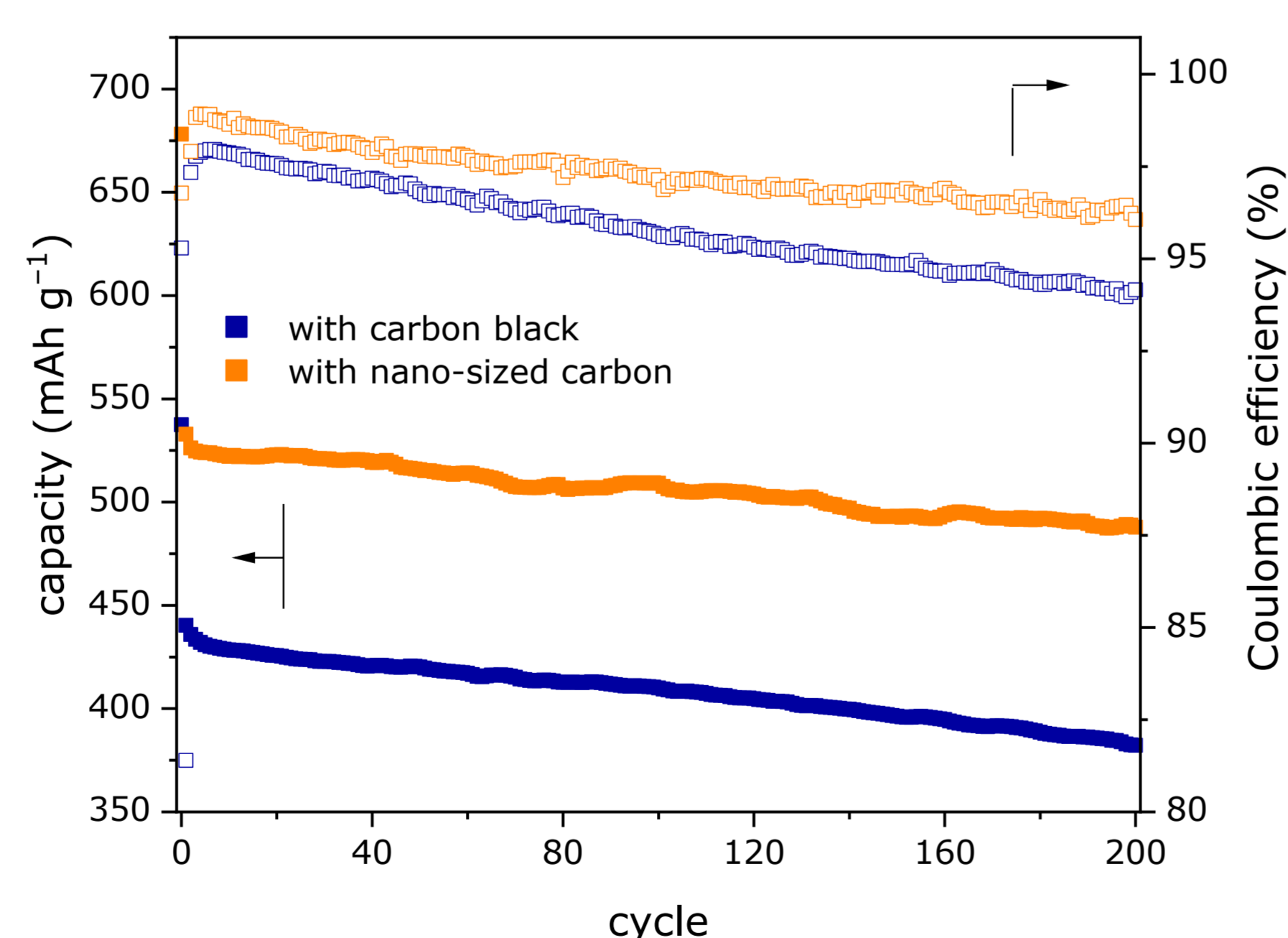


- FT-IR analysis of plasma-polymerized thiophene:
- The higher the power input, the lower the amount of C=C

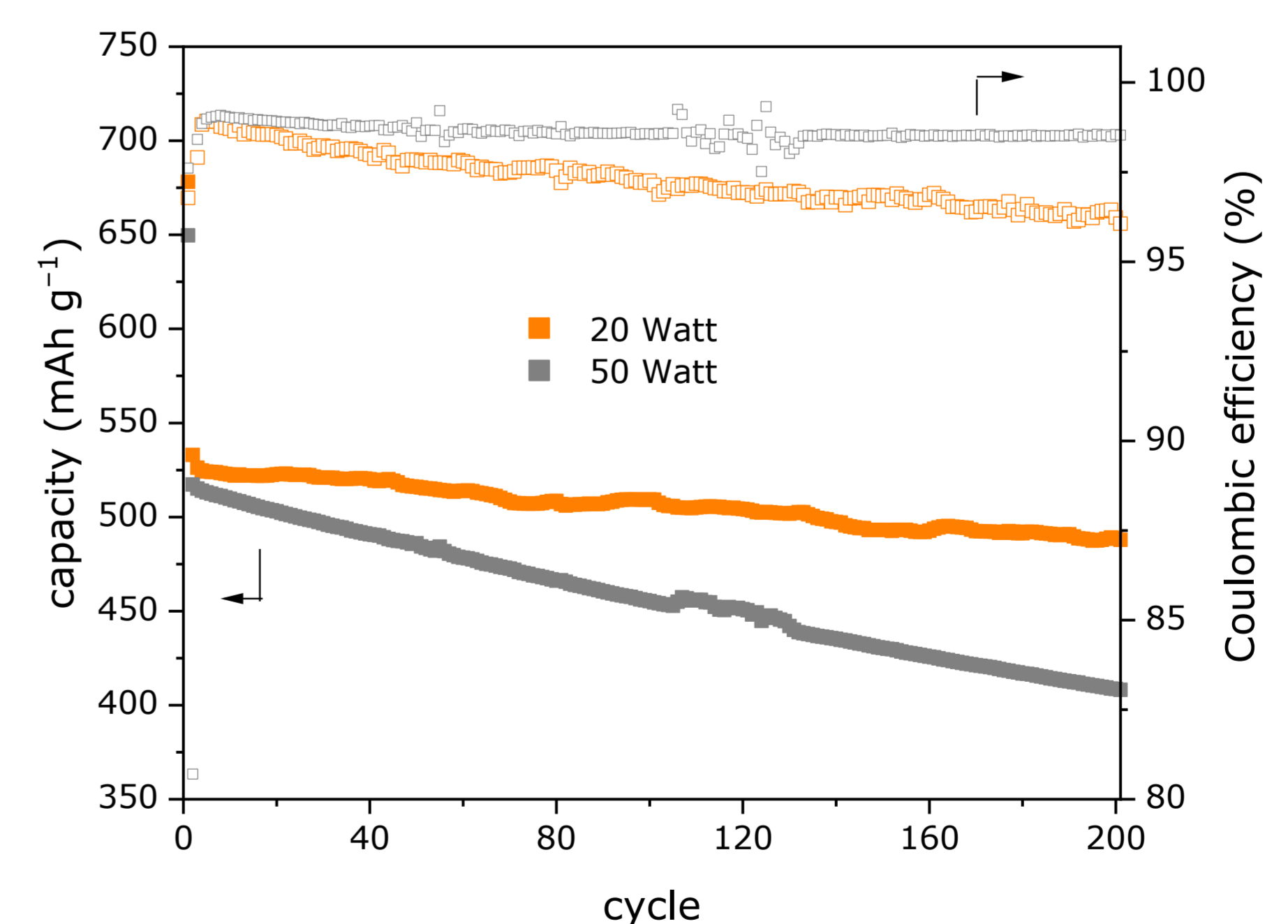


- SEM image of modified Li_2S :
- Cauliflower-like structure after plasma polymer encapsulation

Performance characterization



- Capacity retention and Coulombic efficiency of Li_2S coated with plasma generated polythiophene (blue: Li_2S /carbon black composite, orange: Li_2S /sputtered with nano-sized carbon)
- C-rate: 1 C, 1.85 – 2.8 V
 - Better electrical connection leads to higher capacity, capacity retention and Coulombic efficiency



- Capacity retention and Coulombic efficiency of Li_2S coated with plasma generated polythiophene (grey: plasma power 50 W, orange: plasma power 20 W)
- C-rate: 1 C, 1.85 V – 2.8 V
 - Higher Coulombic efficiency observed with polymer generated with higher plasma power → higher chemical stability
 - Lower capacity retention with 50 W plasma → possible lower mechanical stability

Acknowledgments:

Funded by the Federal Ministry for Economic Affairs and Climate Action on the basis of a decision by the German Bundestag (IGF, project 21006 BG).

References:

- [1] Q. Zou, Y.-C. Lu, *The journal of physical chemistry letters* **2016**, 7, 1518.
 [2] A. F. Hofmann, D. N. Fronczek, W. G. Bessler, *Journal of Power Sources* **2014**, 259, 300.