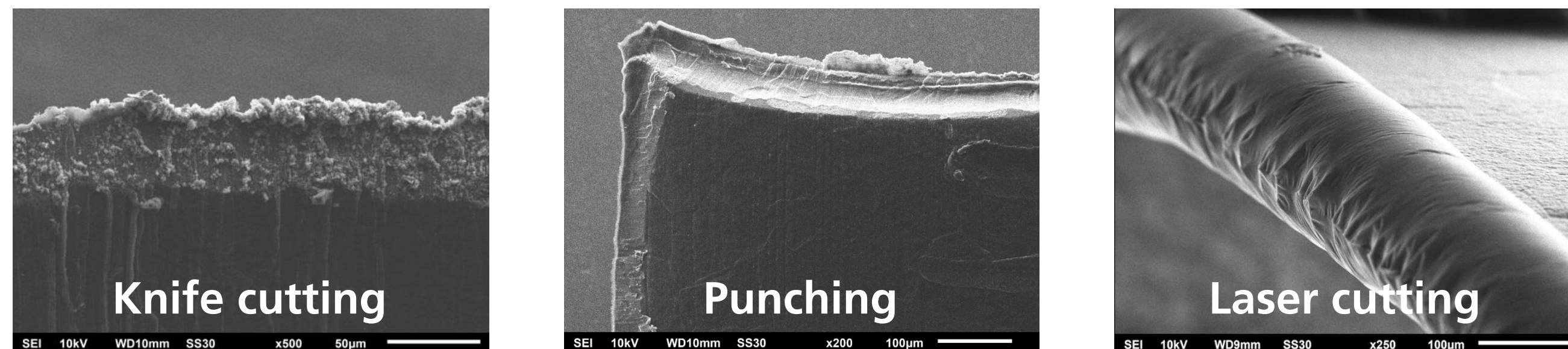


Enhanced Modulated Laser Processing Techniques for Lithium Metal Anodes

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Motivation and Challenges

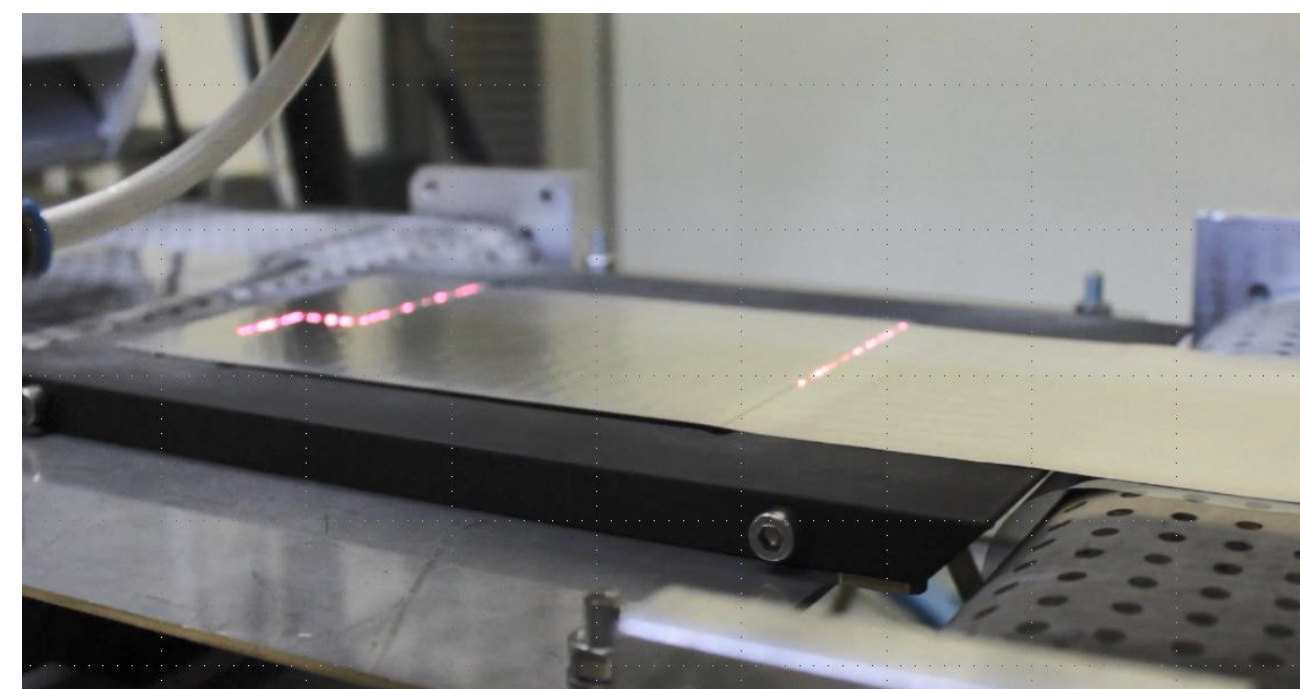
- Overcome limits of recent research work in optimizing electrode cutting edges of pure lithium sheets [1] [2]
- Mechanical treatment like knife or punch cutting of lithium lead to poor edge quality
- Continuous wave laser cutting offers advantages but form bulge-like melt deposits – even use of USP laser systems do not lead to satisfying edges on pure lithium metal or lithium coated copper [3]



Solution and Methods

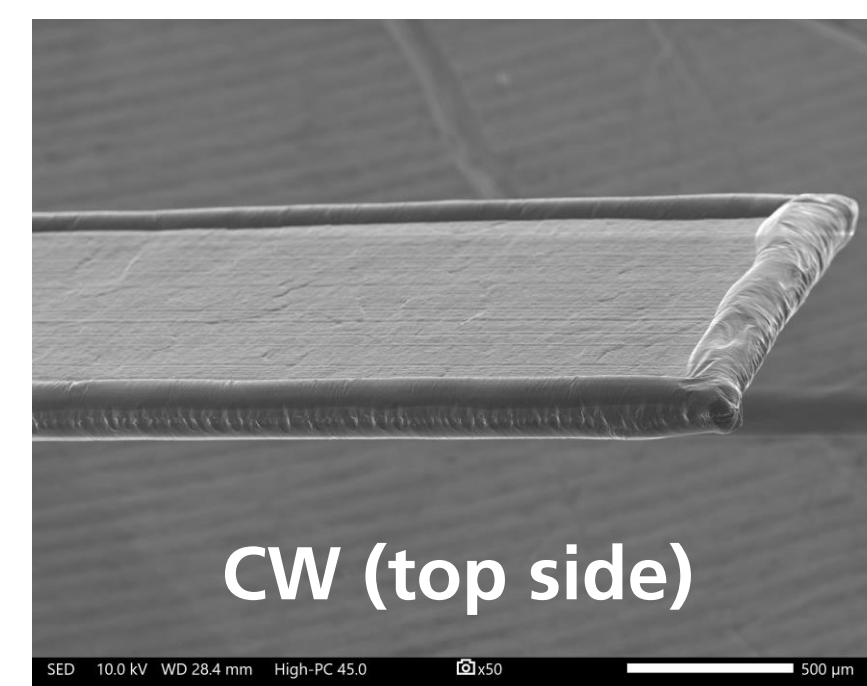
Special processing equipment required

- Dry atmosphere required with dew point < -40°C and particle filtration system
- Gentle handling of lithium foil
- Automated unwinding from reel
- Single mode laser (600 W)



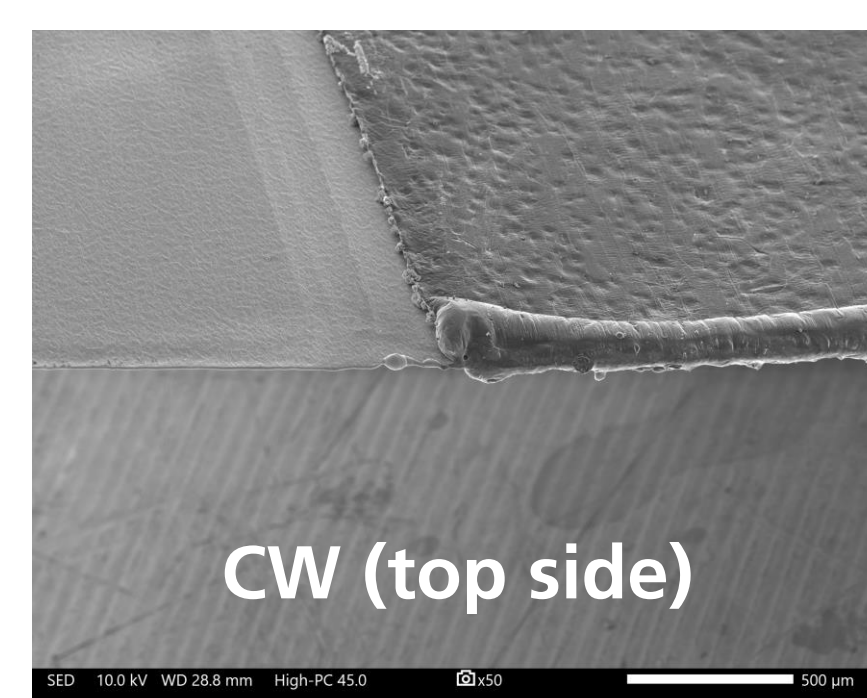
Processing of pure lithium foil

- Laser power: 200 W
- Spot size: 50 µm; velocity of spot: 2 m/s
- Target: 100 µm lithium foil



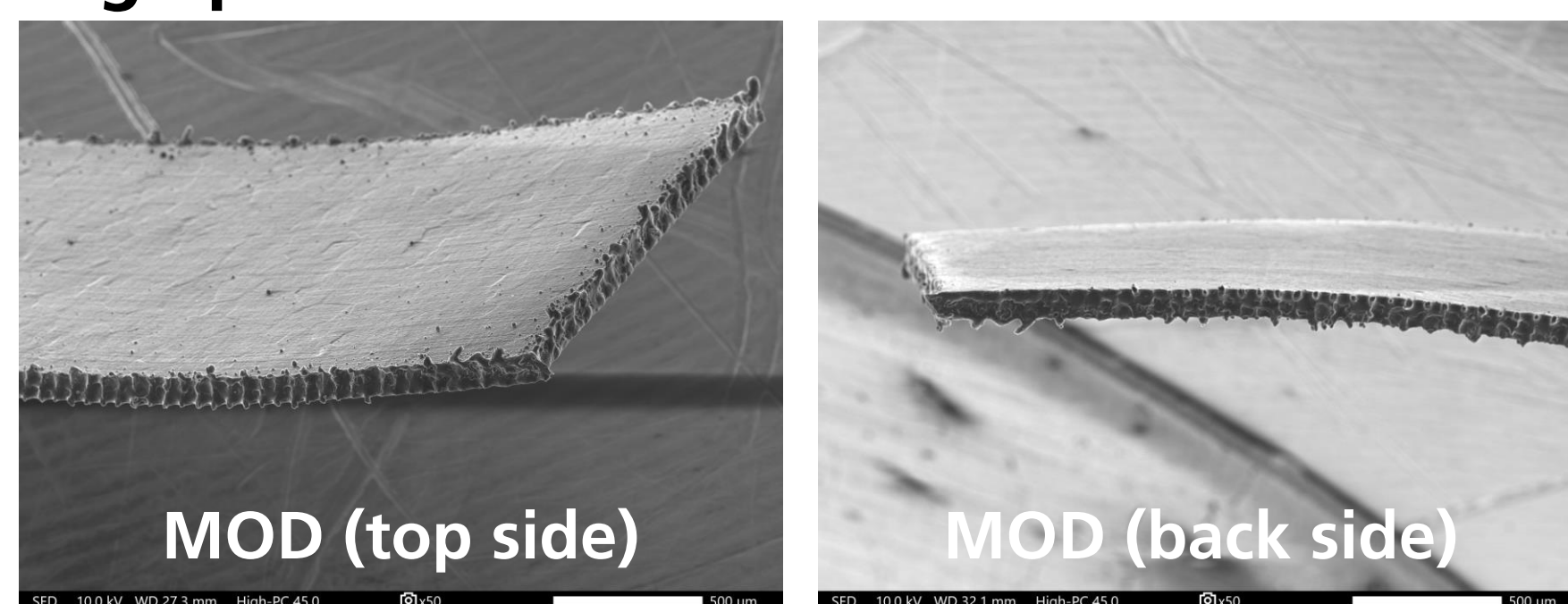
Processing of Li coated copper foil

- Laser power: 400 W (Li surface)
600 W (uncoated copper)
- Process speed of about 2 m/s
- Modulated laser cycling:
40x Li-surface and 1x Cu-surface

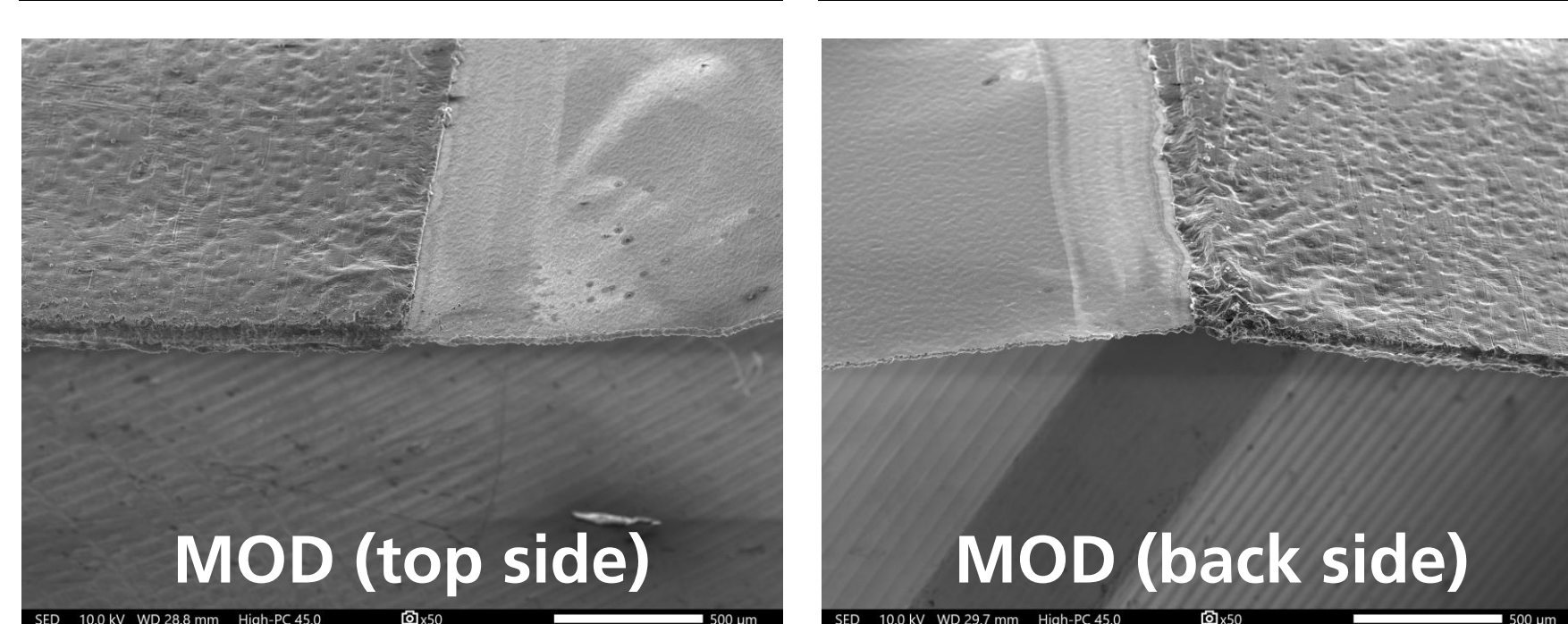


➤ Bulge free cutting edge possible with modulated laser source

100 µm Lithium foil



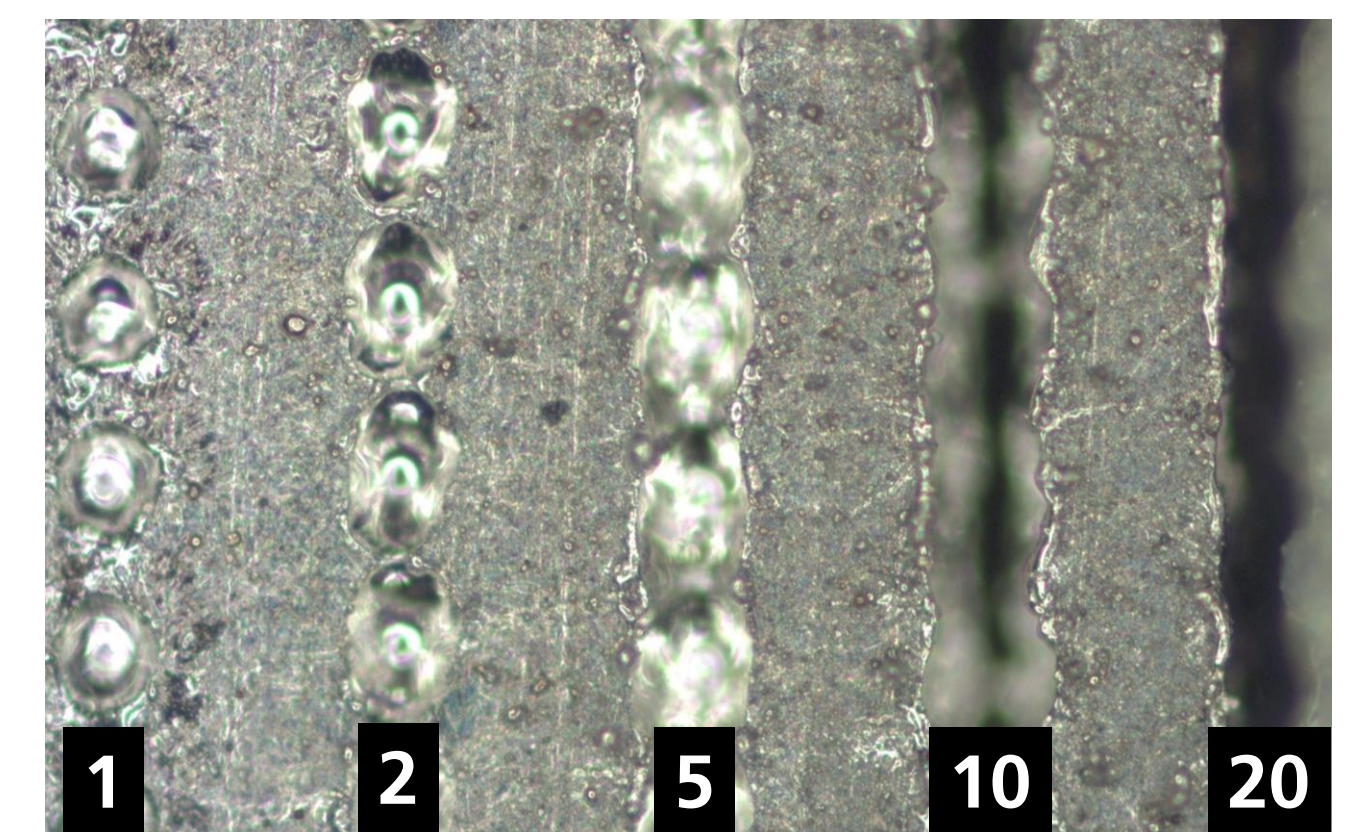
Li coated copper foil



Results

Cutting process plasma sublimation instead of melting

- Modulated laser causes single impacts with various distances
- Mainly sublimation instead of melting of lithium
- No bulge-like melt deposits only little burr along the edge

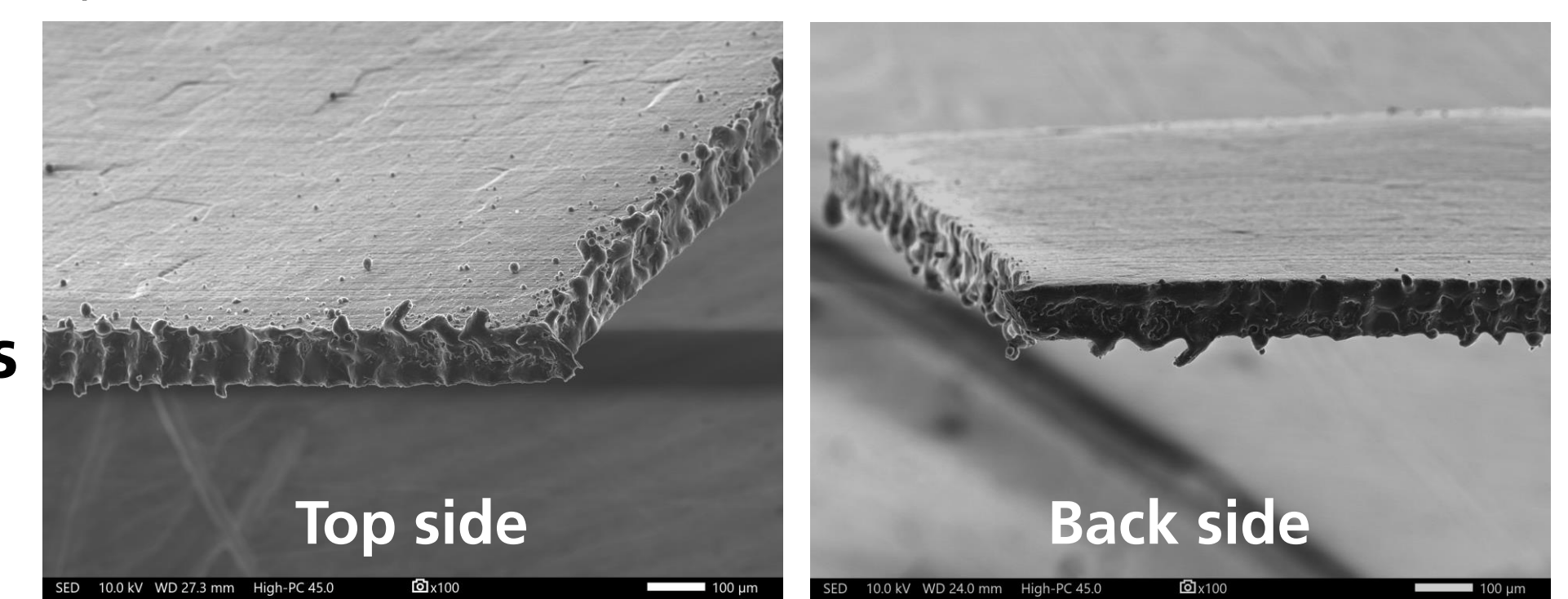


Number of passes: 1 2 5 10 20

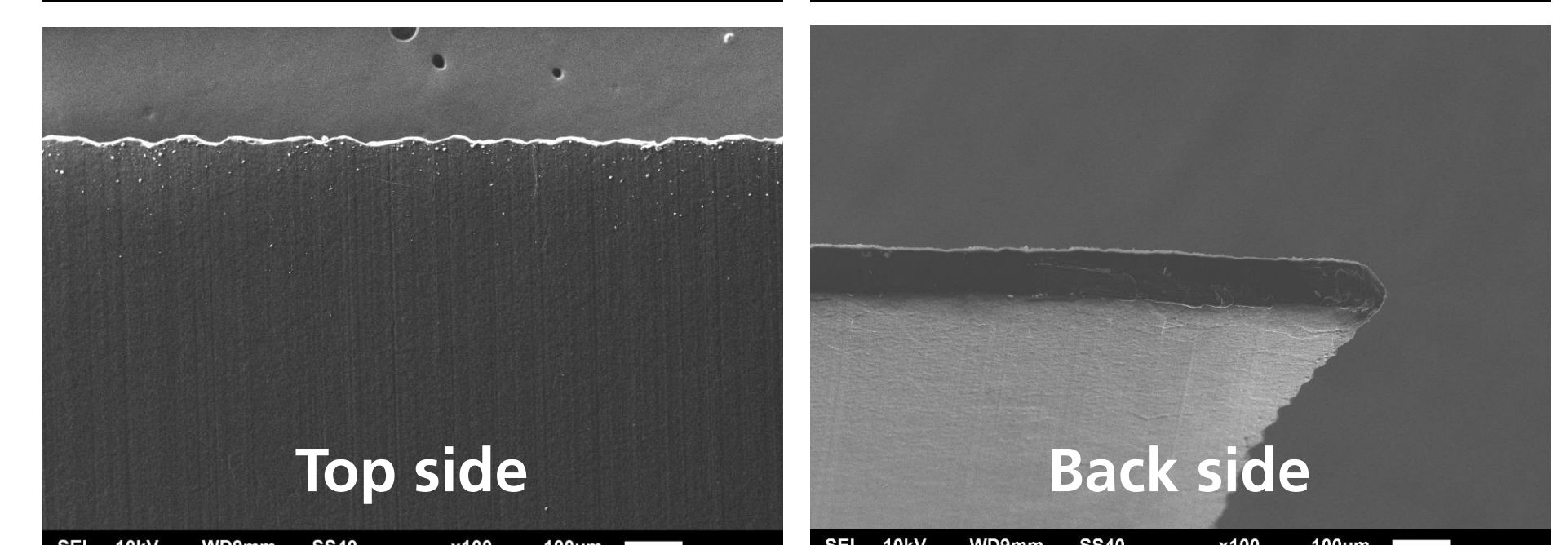
Cutting edge of pure lithium sheets

- Varying process parameters enable optimized edge topography with very slight perforation tooth notches, minimal burrs on the laser side, and low particle deposition on Li surface

Rough cutting edge with defects

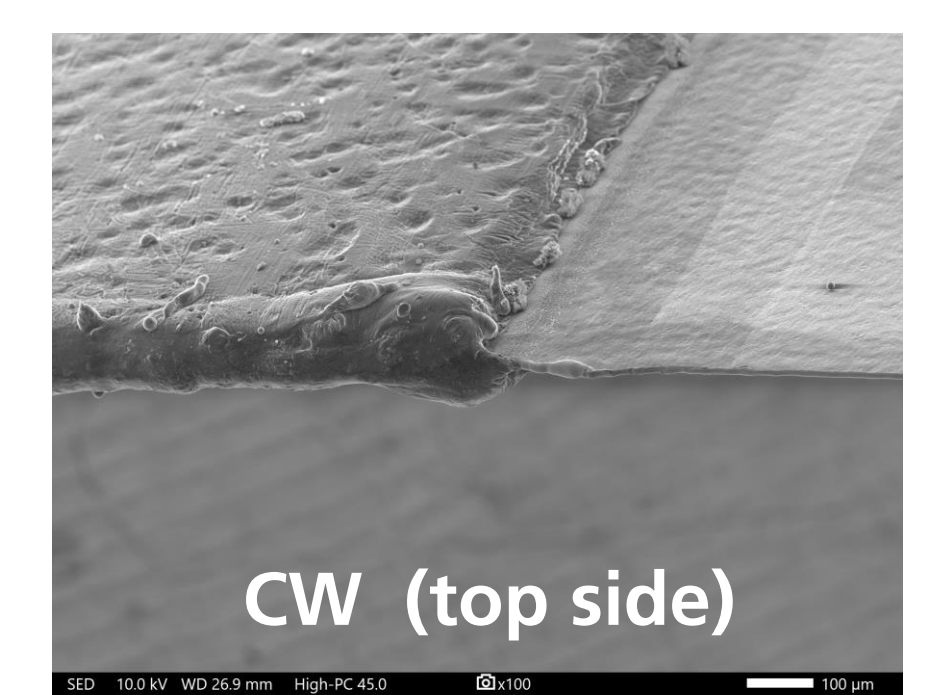


Optimized laser parameters



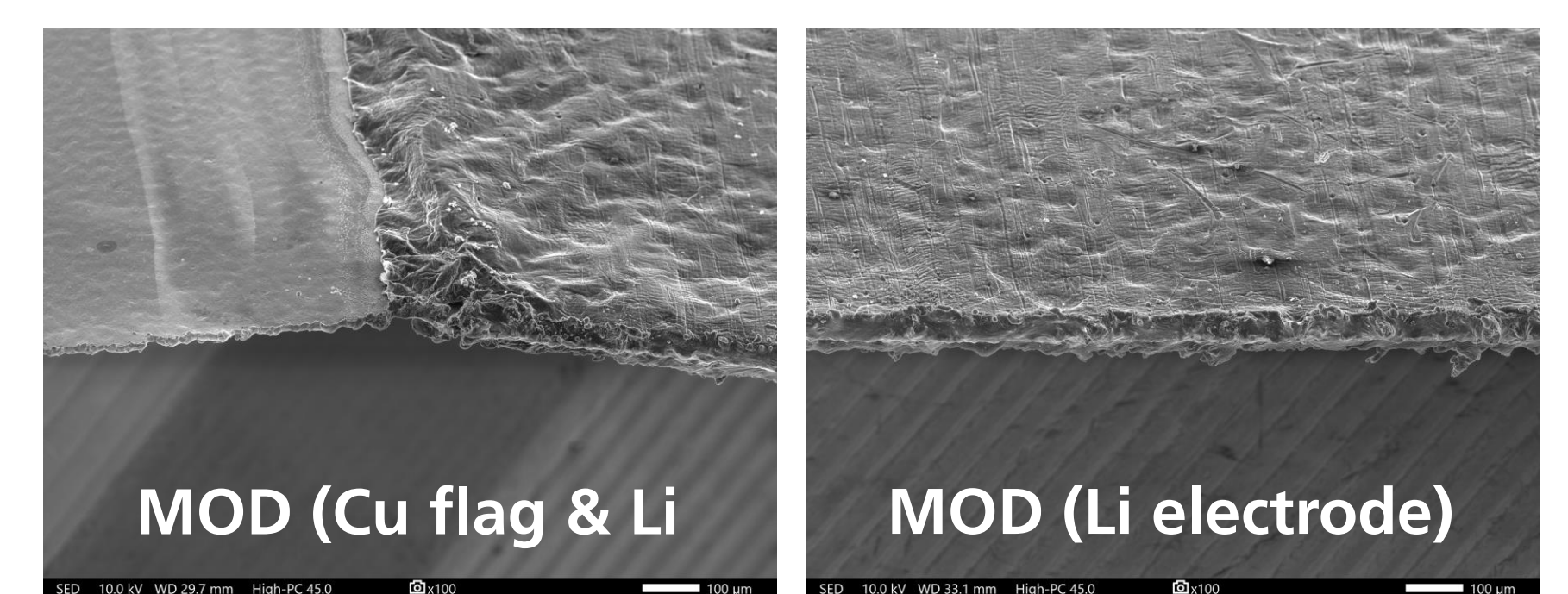
Cutting edge of Li on copper substrate CW mode

- Bulge-like melt deposits along cutting edge almost 2x height of Li coating
- Copper flags show smooth edge with minimal burr



Modulated cutting

- No bulge formation
- Slight burr
- Copper flag with gentle pit marks



Conclusion and Outlook

- Bulge free laser cutting of Li anodes for next gen batteries
- Li and Li coated Cu can be processed in single laser treatment step
- Active patent: EP4313470B1[4]
- Fully automated laser cutting, stacking and joining for up to 25 Ah Li-metal pouch cells demonstrated at Fraunhofer IWS



[1] Kriegl, J., Duy Nguyen, T. M., Tomcic, L., Hille, L., Grabmann, S., Jaimez-Farnham, E. I., & Zaeh, M. F. (2022). Processing of lithium metal for the production of post-lithium-ion batteries using a pulsed nanosecond fiber laser. Results in Materials, 15, Article 100305 <https://doi.org/10.1016/j.rinma.2022.100305>

[2] Patent CN118492649A Lithium metal electrode processing method, device and battery

[3] Schmidt, L.O.; Wehbe, H.; Hartwig, S.; Kandula, M.W. Investigation of the Laser Material Interaction of Lithium Copper Foils Under Different Process Gases for All-Solid-State Batteries. Batteries 2025, 11, 195. <https://doi.org/10.3390/batteries11050195>

[4] Patent DE 10 2021 202 964.7 Verfahren und Vorrichtung zum Schneiden einer metallhaltigen Folie und Laser-geschchnittene metallhaltige Folie

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