

Polymer based conducting films for battery applications



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Application of conductive films

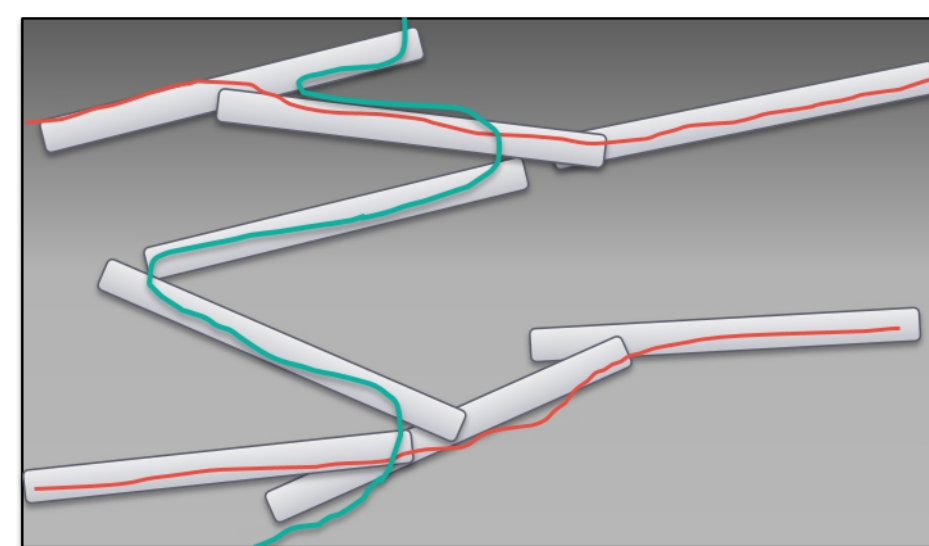
- Research focus on the development of components for large-format planar bipolar batteries (EMBATT concept), e.g. for the automotive sector
- Recipe development of polymer based film as an **alternative to the aluminium foils** used so far
- Goal: Continuous production of homogeneous thin films on large-scale

Challenges in the development

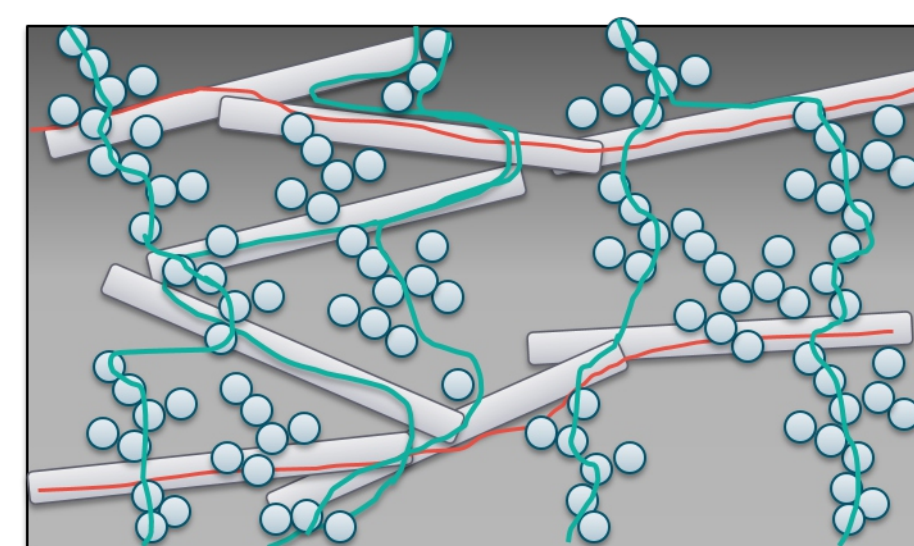
Requirements: Homogeneous surface quality and high electrical conductivity through thin (<100 µm) films

Filler orientation

only 1D fillers:
mainly conductive pathways in
extrusion direction



1D fillers & 3D fillers:
conductive pathways in all
directions

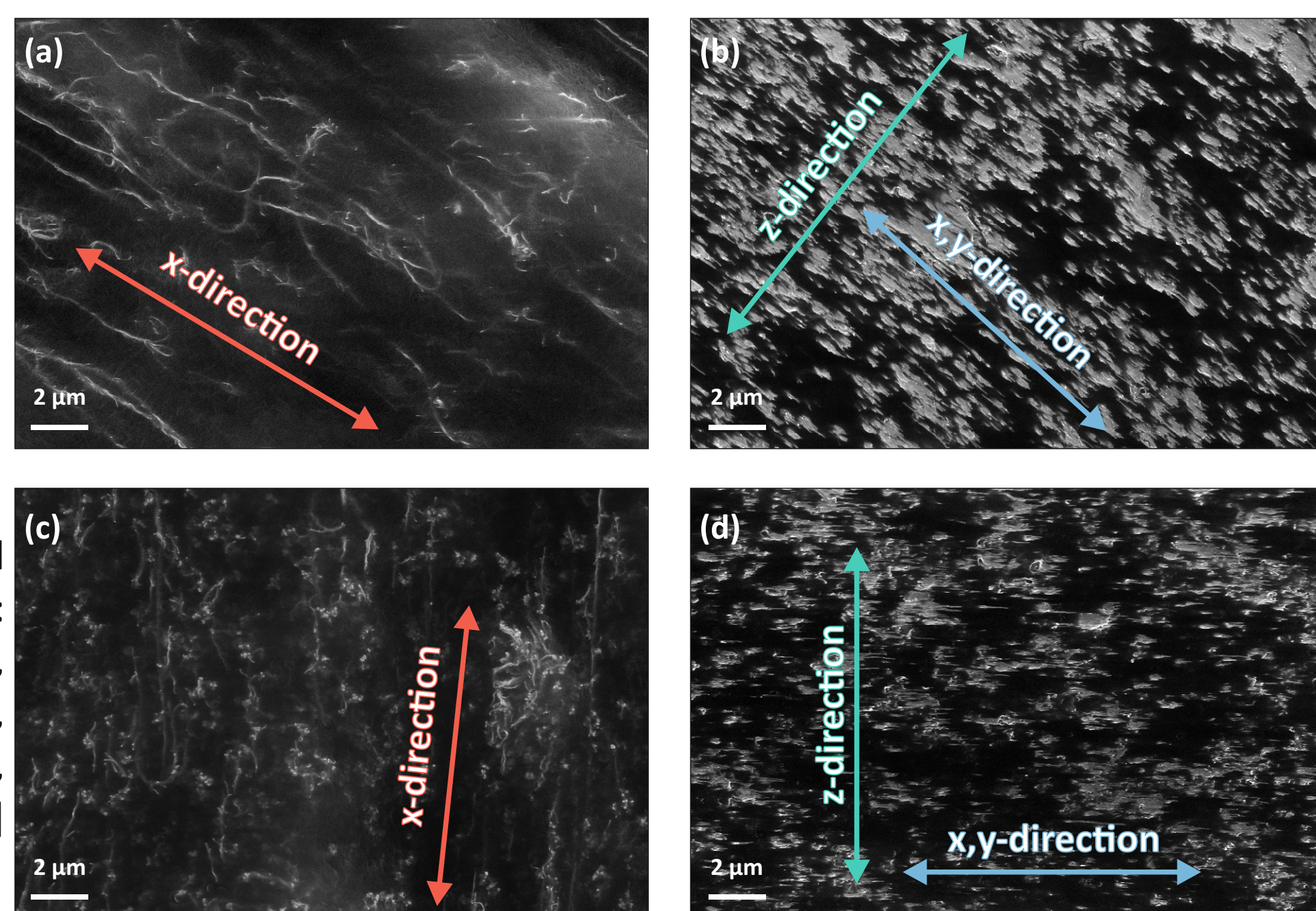


in extrusion direction (x)

through
the film
(z)

Challenge: Filler orientation depends on the shape of the filler, resulting in direction-dependent electrical conductivities

- 1D fillers such as **carbon nanotubes (CNTs)** are oriented in the stretching direction → conductive pathways mainly in the extrusion direction and hardly through the film thickness
- 3D fillers such as conductive **carbon black (CB)** are less oriented → conductive pathways in all directions [1, 2]



SEM-CCI images of extruded PVDF films filled with:
(a, b) 2 wt% MWCNT,
(c, d) 1 wt% MWCNT + 1 wt% CB,
(a, c) surface,
(b, d) cross-section [2]

Projects:

- BMBF-Project 03XP00068-E „EMBATT2.0 - Material- und Prozessentwicklung für die effiziente Fertigung der großformatigen Bipolarbatterie EMBATT“, cooperation project with Glatt Ingenieurtechnik GmbH, IAV GmbH, Fraunhofer IKTS Dresden, IPF Dresden e.V., Isocoil Chemie GmbH, KMS Technology Center GmbH, Litarion GmbH, thyssenkrupp System Engineering GmbH, ULT AG, duration: 07/2016 - 09/2019
- AIF-ZIM Project ZF4028415ZG8 „Planare Materialien für Batteriekomponenten für Automobile Anwendungen (PLANAR MABAT)“, cooperation project with Eisenhuth GmbH & Co. KG, duration: 03/2019 - 06/2021
- BMW-Project 03ETE043D „BiPoLiS - Entwicklung von Lithium-Schwefel-Bipolarbatterien“, cooperation project with LioVolt GmbH, Eisenhuth GmbH & Co. KG, Fraunhofer Institute for Material and Beam Technology IWS, IPF Dresden e.V., duration: 01/2023 - 12/2025

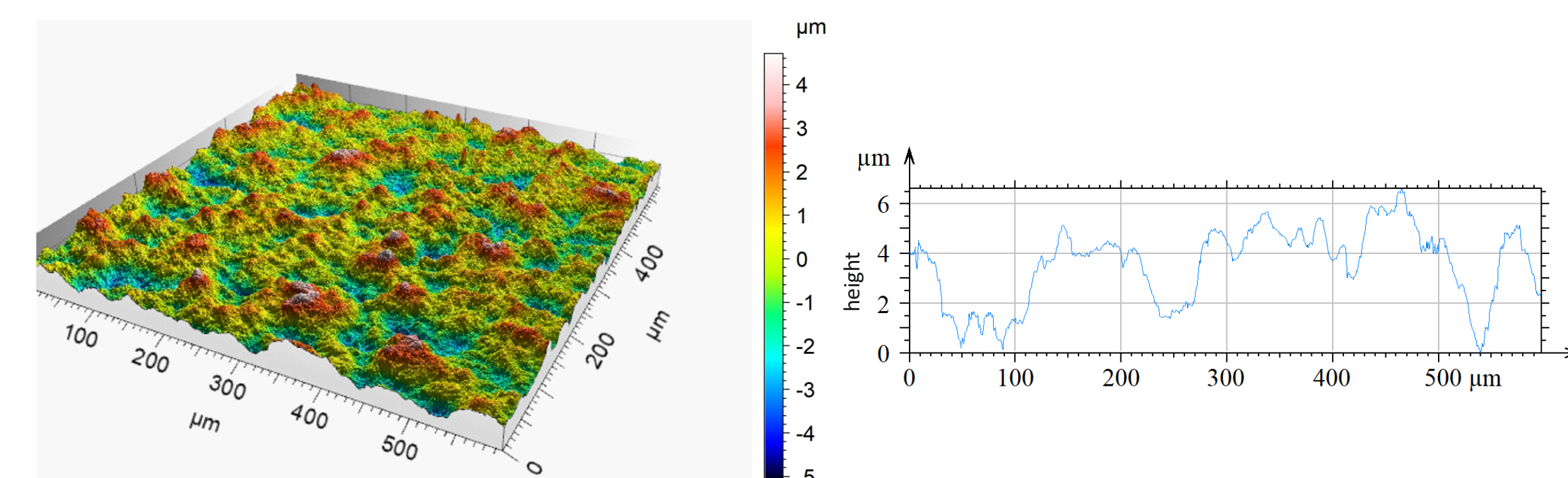
Upscaling and cell preparation

- Laboratory scale production (variation of processing conditions):
 - ★ 50 µm thin homogeneous films
 - ★ Through-film conductivity of approx. 1 S/m
 - ★ In-film conductivity of approx. 100 S/m
- Proof of the polymer based conducting films in Swagelok cells [3]

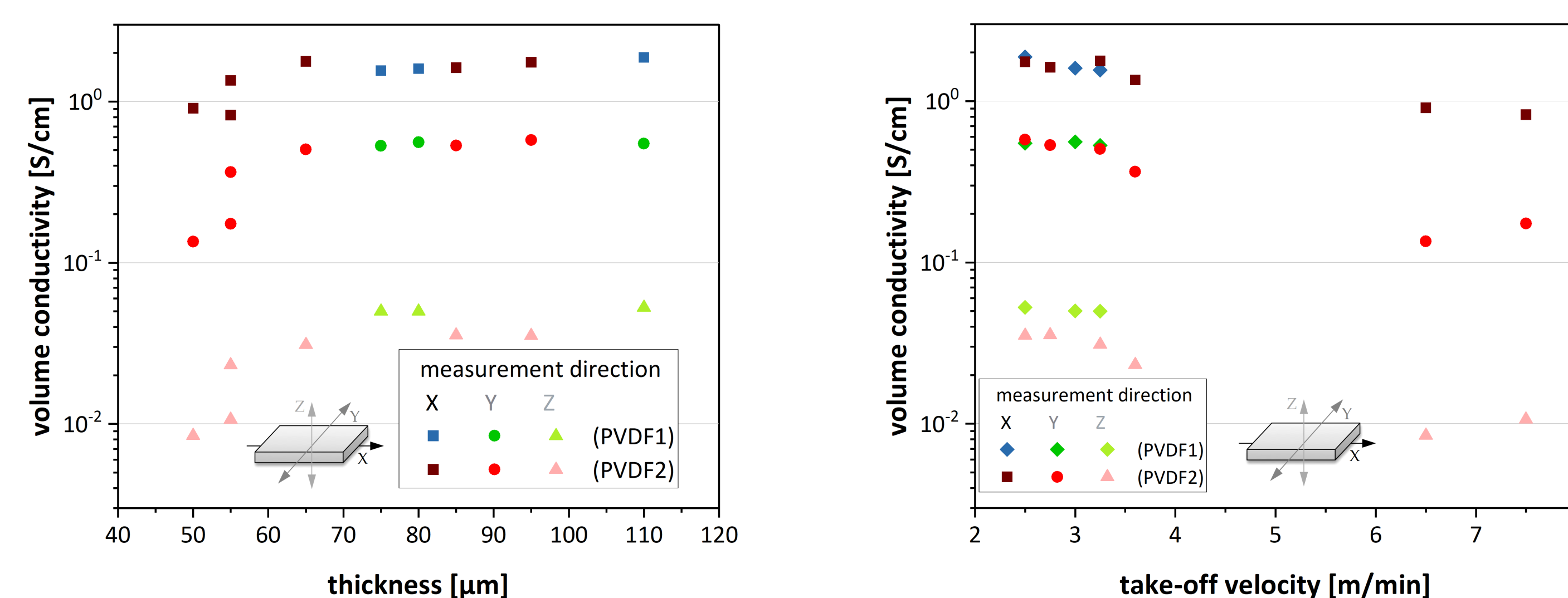
- Polymer based conductive films (PVDF, PP) represent a suitable alternative to aluminium foils



Surface topography and roughness of a large-scale extruded PVDF composite film [3]



Volume conductivity in large-scale produced PVDF films is depending on film thickness and take-off velocity:
PVDF/1 wt% MWCNTs + 3 wt% CB composites based on two different PVDF types [2]



References:

- [1] Karina Kunz, Beate Krause, Bernd Kretschmar, Levente Juhasz, Oliver Kobsch, Wolfgang Jenschke, Mathias Ullrich, Petra Pötschke, Direction dependent electrical conductivity of polymer/carbon filler composites, *Polymers* **2019**, 11 (4), 591. <https://doi.org/10.3390/polym11040591>
- [2] Beate Krause, Karina Kunz, Bernd Kretschmar, Ines Kühnert, Petra Pötschke, Effect of Filler Synergy and Cast Film Extrusion Parameters on Extrudability and Direction-Dependent Conductivity of PVDF/Carbon Nanotube/Carbon Black Composites, *Polymers* **2020**, 12 (12), 2992. <https://doi.org/10.3390/polym12122992>
- [3] Marco Fritsch, Matthias Coeler, Karina Kunz, Beate Krause, Peter Marcinkowski, Petra Pötschke, Mareike Wolter, Alexander Michaelis, Lightweight polymer-carbon composite current collector for lithium-ion Batteries, *Batteries* **2020**, 6 (4), 60. <https://doi.org/10.3390/batteries6040060>

