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Polymer based conducting films for battery applications

P. Pötschke[1], B. Krause[1], I. Kühnert[2]

[1]Institute of Macromolecular Chemistry, Department Functional Nanocomposites and Blends, [2]Institute of Polymer Materials, Department Processing Technology

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

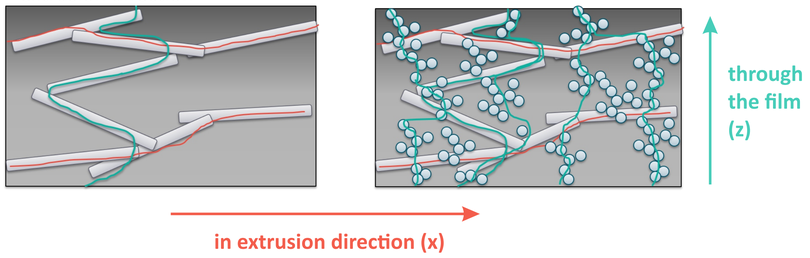
Challenges in the development

Requirements: Homogeneous surface quality and high electrical conductivity through the film.

Filler orientation

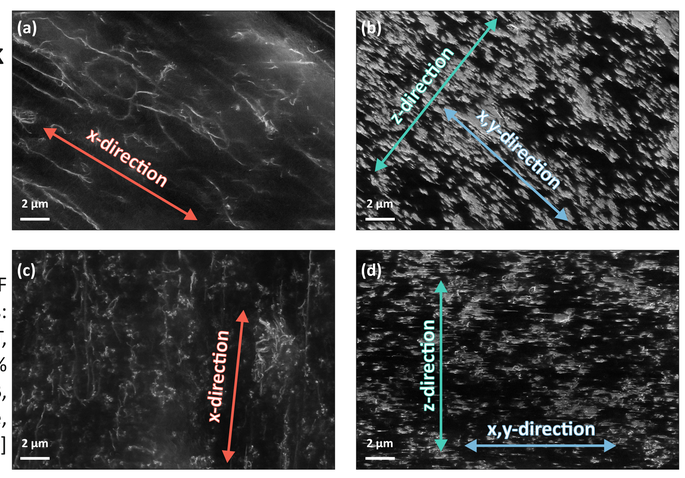
only 1D fillers:
mainly conductive pathways in extrusion direction

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



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

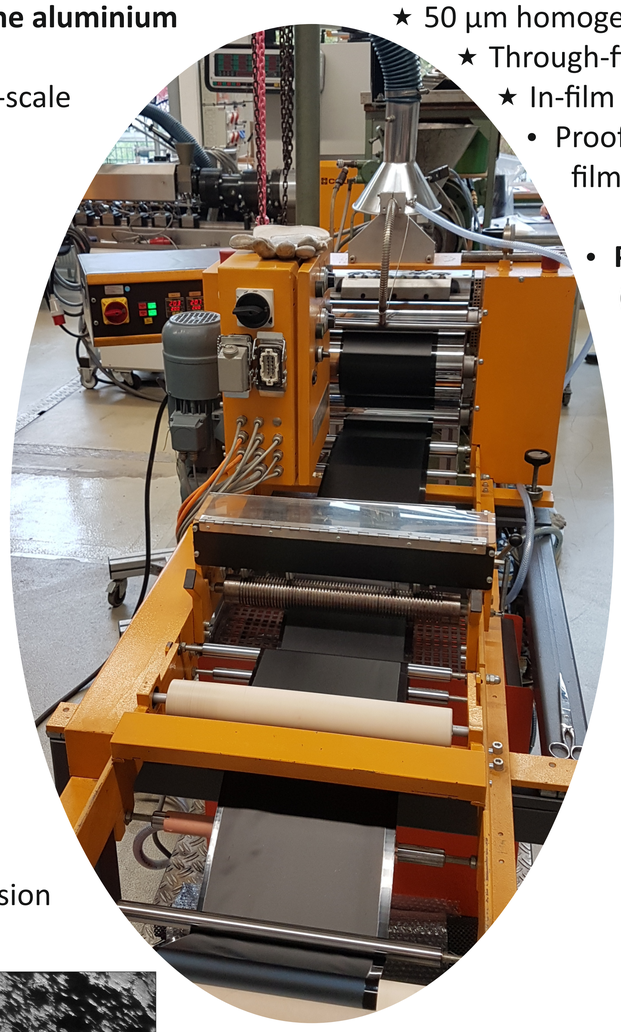
- 1D fillers such as **carbon nanotubes (CNTs) are oriented** in the stretching direction ⟶ conductive pathways mainly in the extrusion direction and hardly through the film thickness
- 3D fillers such as conductive **carbon black (CB) are less oriented** ⟶ conductive pathways in all directions [1, 2]



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

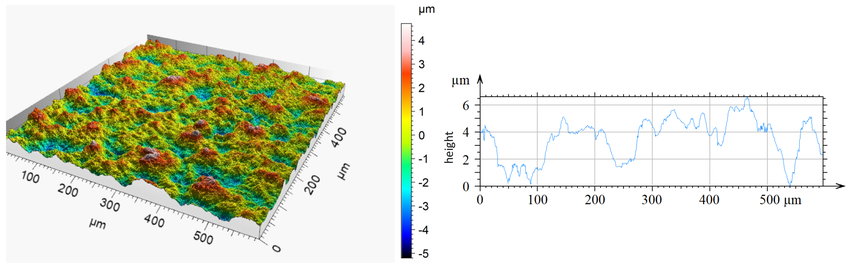
Upscaling and cell preparation

- Laboratory scale production (variation of processing conditions):
  - ★ 50 µm 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]



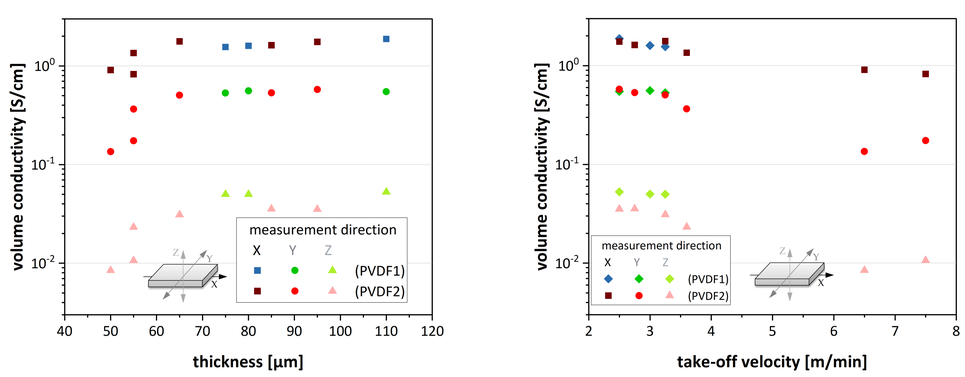
- **Polymer based conductive films (PVDF, PP) represent a suitable alternative to aluminium foils**

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% b-MWCNTs + 3 wt% CB composites based on two different PVDF types [2]



Projects:

- BMBF-Projekt 03XP00068-E „EMBATT2.0 - Material- und Prozessentwicklung für die effiziente Fertigung der großformatigen Bipolarbatterie EMBATT (Material and process development for the efficient production of the large-format bipolar battery EMBATT)“, cooperation project with Glatt Ingenieurtechnik GmbH, IAV GmbH, Fraunhofer IKTS Dresden, IPF Dresden, Isocoll Chemie GmbH, KMS Technology Center GmbH, Litarion GmbH, thyssenkrupp System Engineering GmbH, ULT AG, duration: 07/2016 - 09/2019
- AIF-ZIM Projekt ZF4028415ZG8 „Planare Materialien für Batteriekomponenten für Automobile Anwendungen (Planar materials for battery components for automotive applications) (PLANAR MABAT)“, TP: Materialentwicklung für elektrisch leitfähige Durchleiterfolien zur Anwendung in Batterien (Material development for electrically conductive films for use in batteries), cooperation project with Eisenhuth GmbH & Co. KG, duration: 03/2019 - 06/2021

References:

[1] Karina Kunz, Beate Krause, Bernd Kretzschmar, 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 Kretzschmar, 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