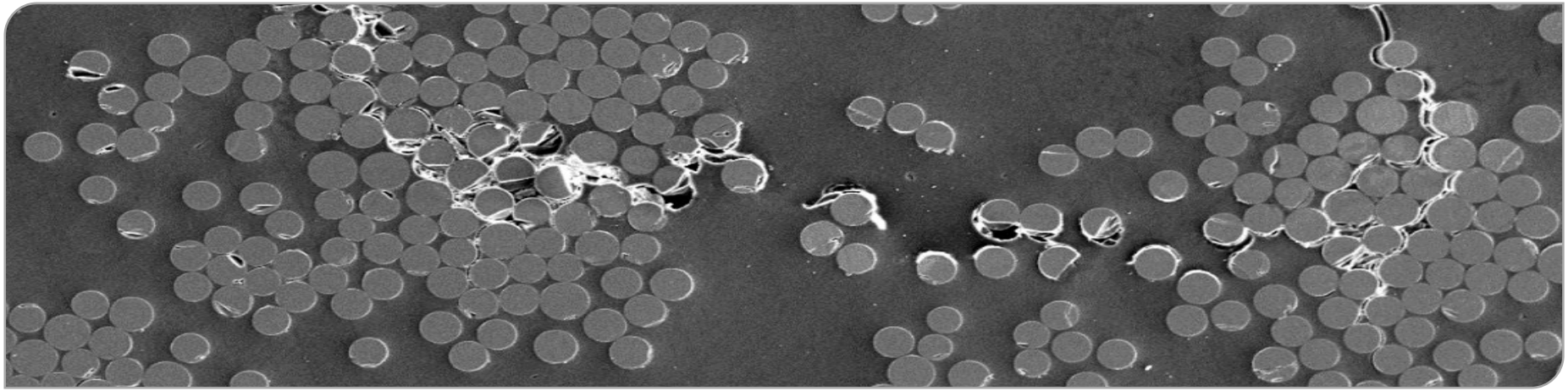
Karlsruhe Institute of Technology

Characterization and Simulation of the Interface Between Continuously and Discontinuously Fiber Reinforced Thermoplastics

Nicolas Christ, Benedikt Scheuring, John Montesano, Jörg Hohe



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  - Influence of Humidity
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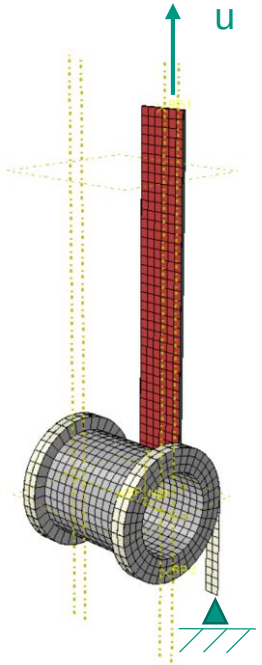
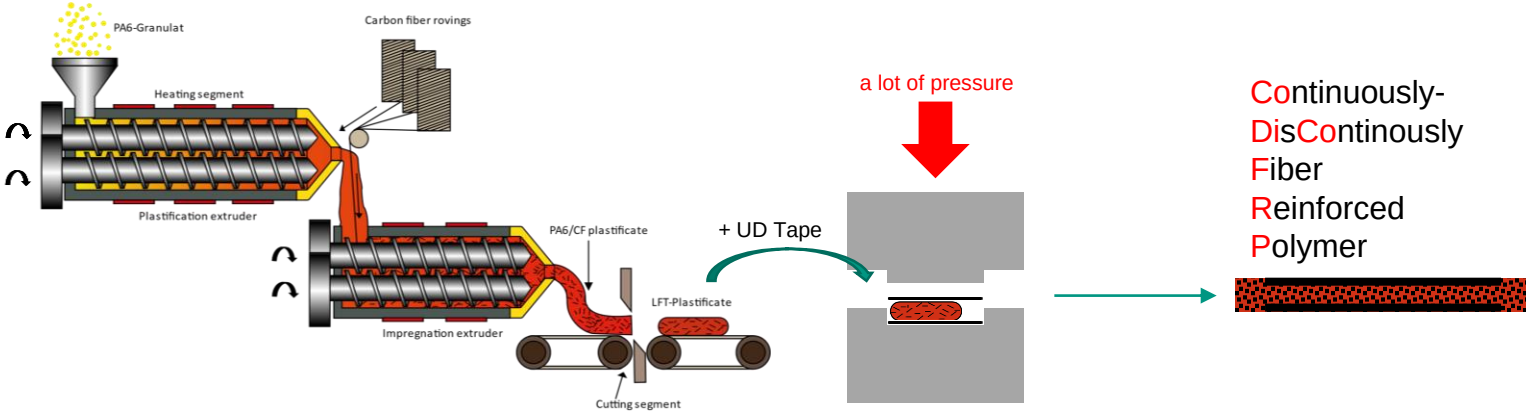


Thermoplastic Co-DiCo FRP

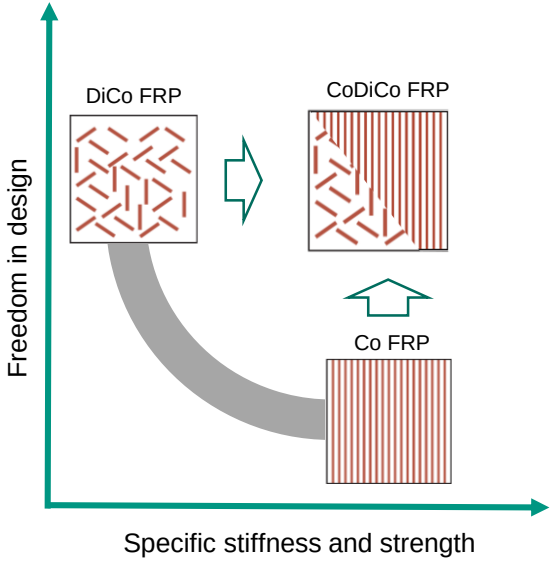
- Material: Polyamide 6 (PA6) + Carbon Fiber
- Process: LFT-D

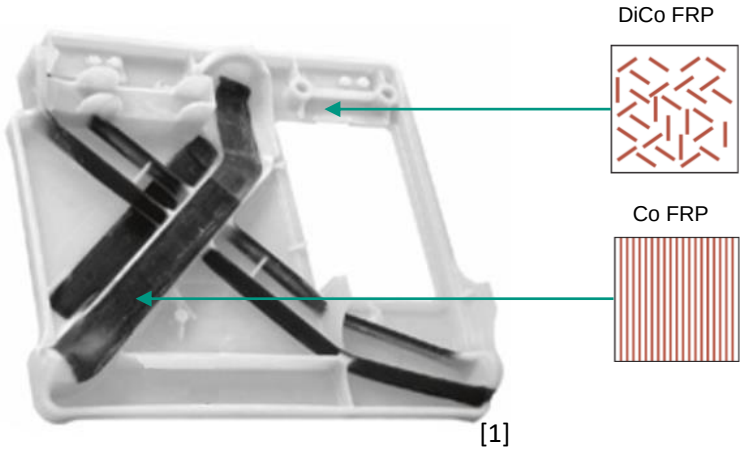


Motivation → Method → Results → Outlook

Thermoplastic Co-DiCo FRP

- Why CoDiCo?

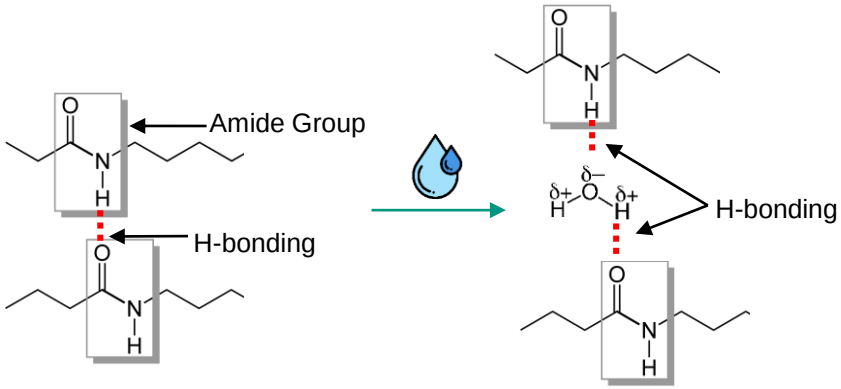




[1]

Thermoplastic Co-DiCo FRP

- Water absorption in PA6



Increase in distance

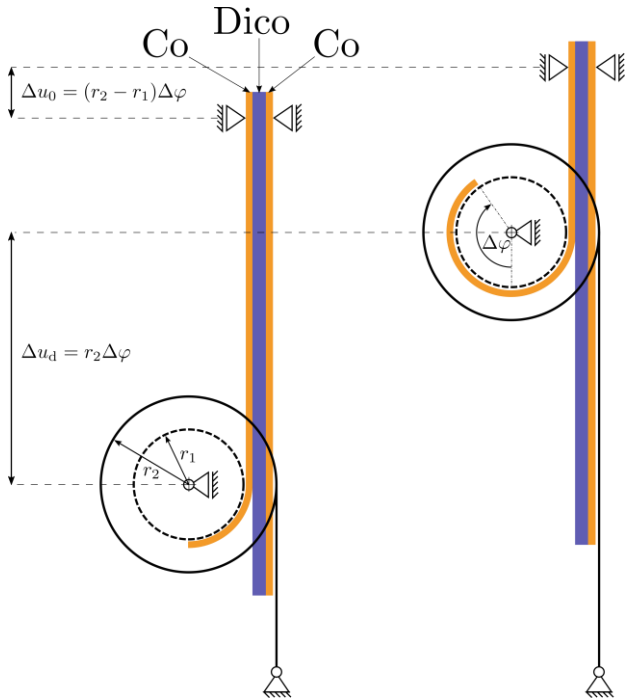
[2]

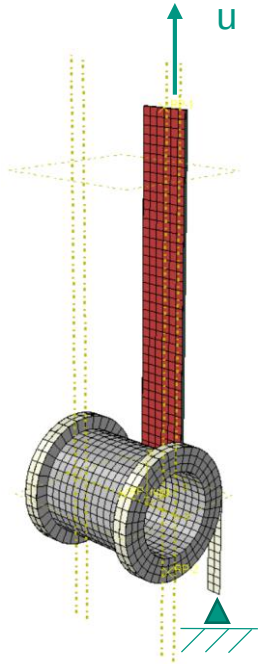
Thermoplastic Co-DiCo FRP

- Interface characterization
  - Available experiments
    - Normal direction
      - Double Cantilever Beam (DCB)
      - Climbing Drum Peel Test (CDP)
    - Shear direction
      - End Notched Flexure Test (ENF)
      - Interlaminar Shear Strength Test (ILSS)

Climbing Drum Peel Test

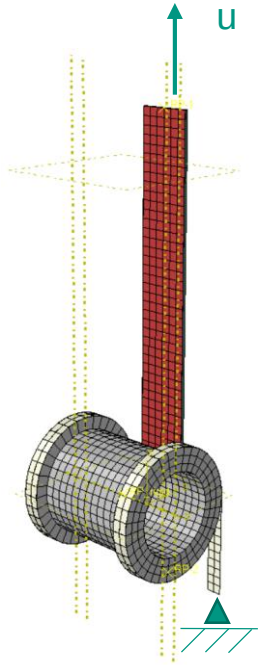
- Kinematics





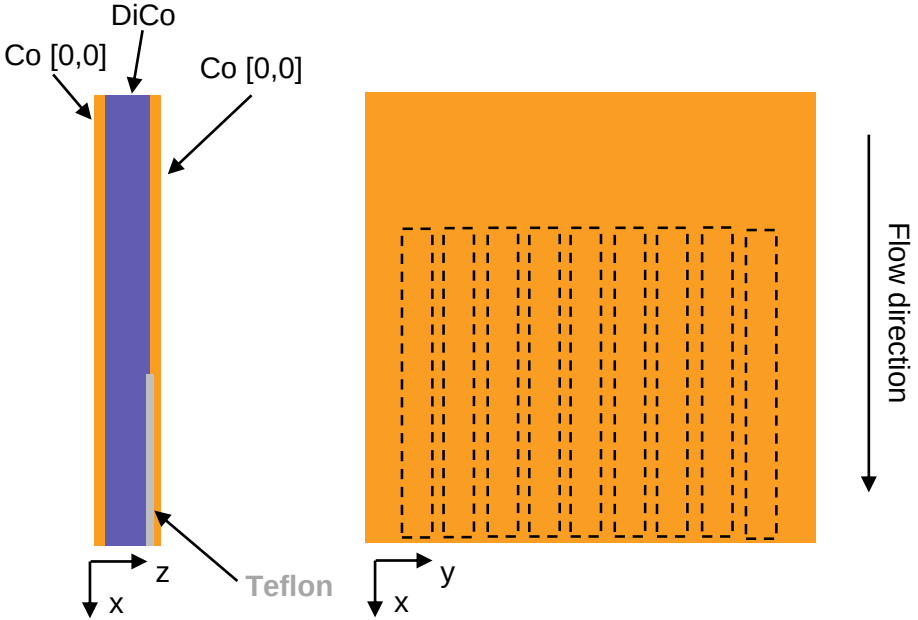
Climbing Drum Peel Test

- Experimental Setup

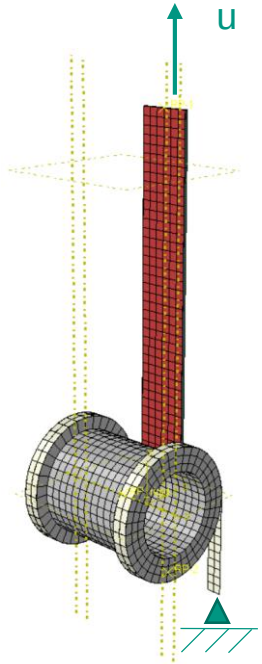


Climbing Drum Peel Test

- Specimens



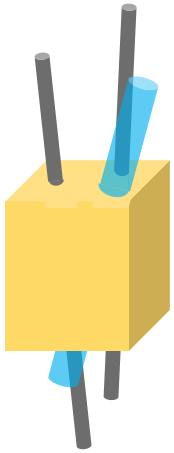
- Type A: vacuum dried
- Type B: conditioned at 75% r.H. and 50°C



Motivation → Method → Results → Outlook

Climbing Drum Peel Test

- Numerical Setup
  - Extensive study on material properties (fiber content, orientation, …)

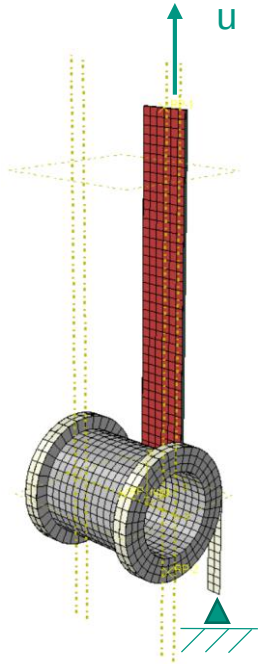


HomoPy

Mori-Tanaka → DiCo (continuum)

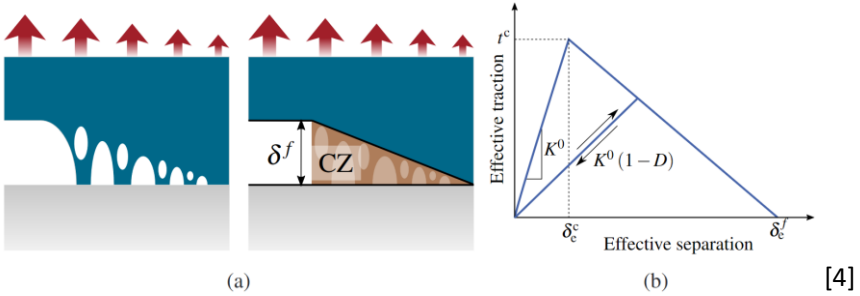
Halpin-Tsai → Co (laminate)

[3]



Climbing Drum Peel Test

- Numerical Setup
  - Extensive study on material properties (fiber content, orientation, …)
  - Interface modelled with Cohesive Surface



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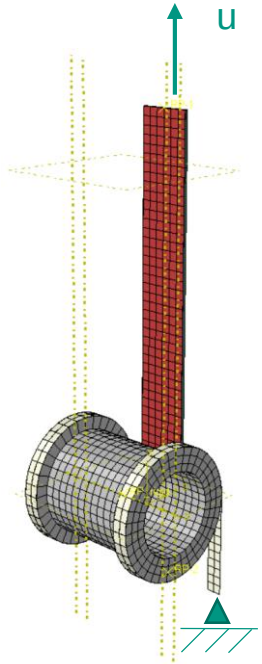
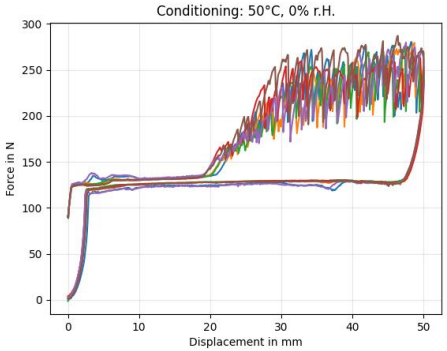
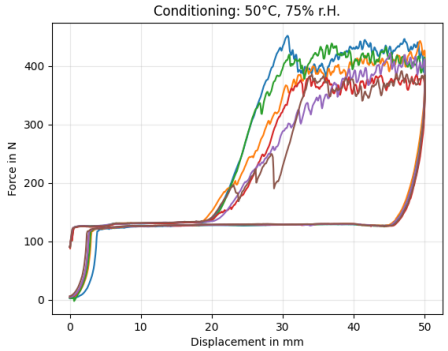


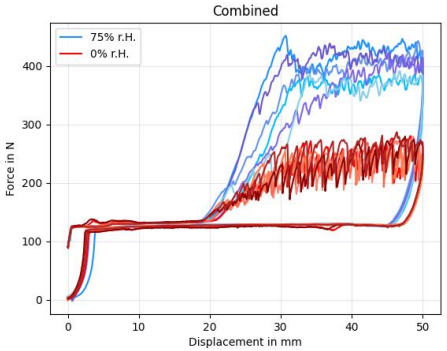
Motivation → Method → Results → Outlook

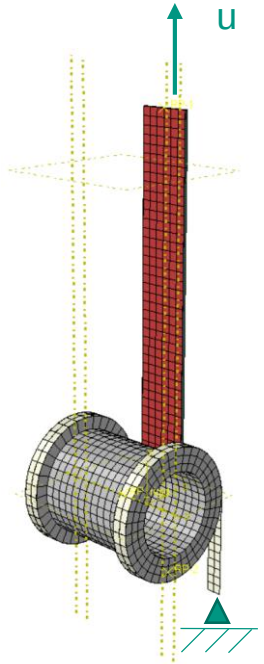
Results

- Experimental: Force over Displacement









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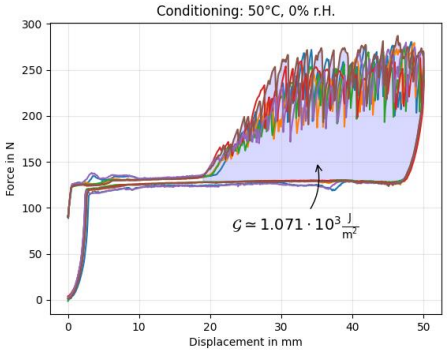
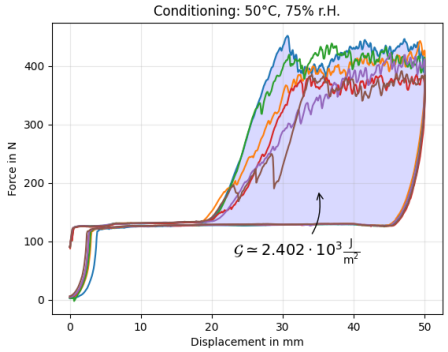
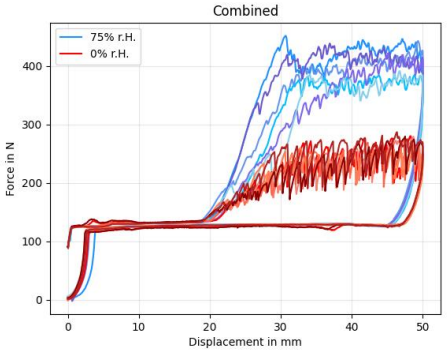
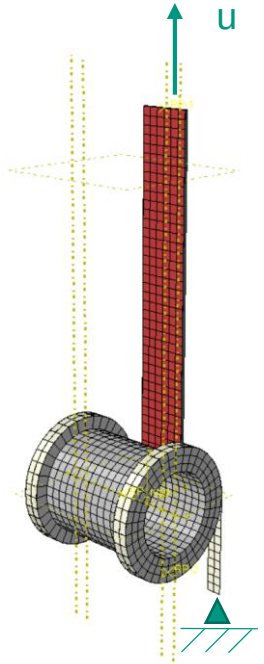




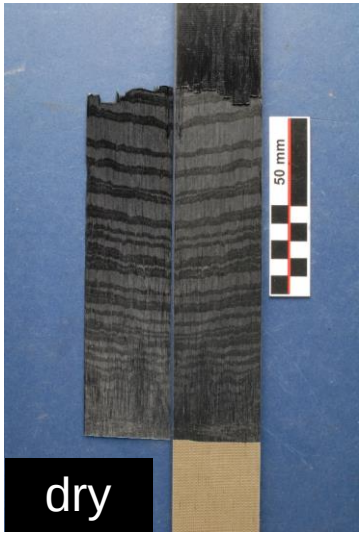




Motivation → Method → Results → Outlook

Results

- Fractography



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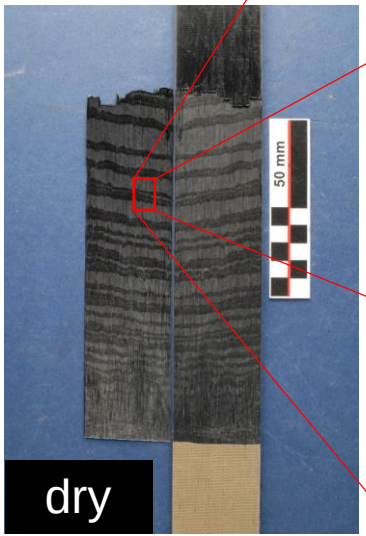

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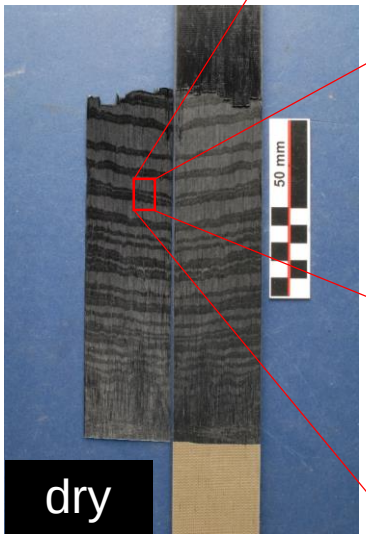

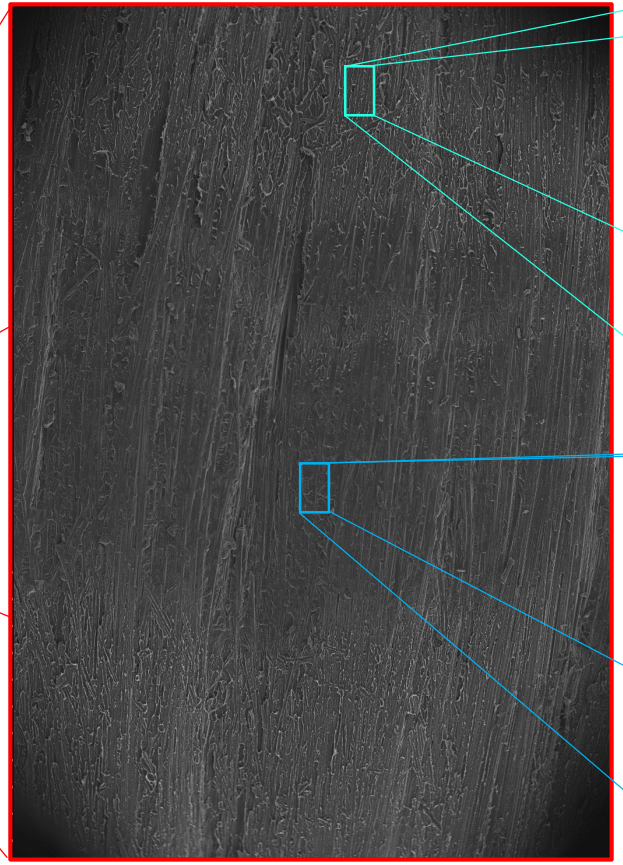

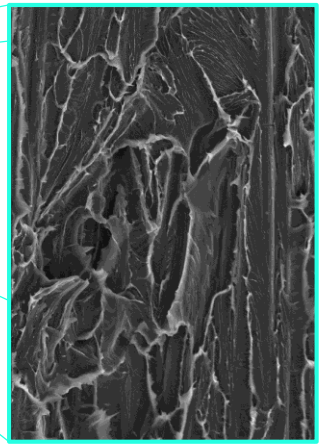

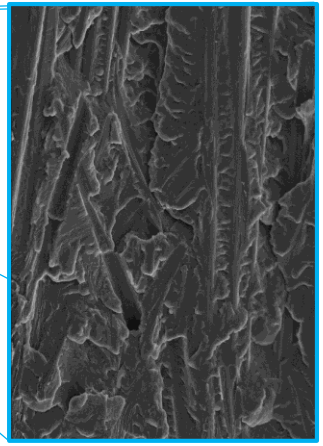

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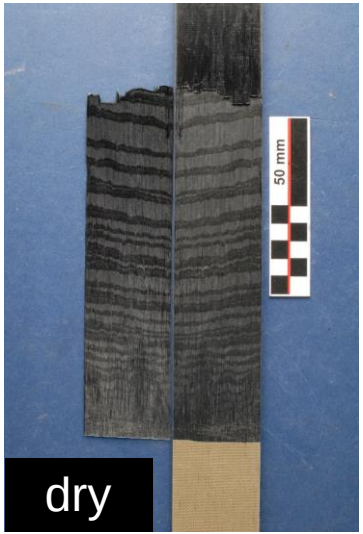

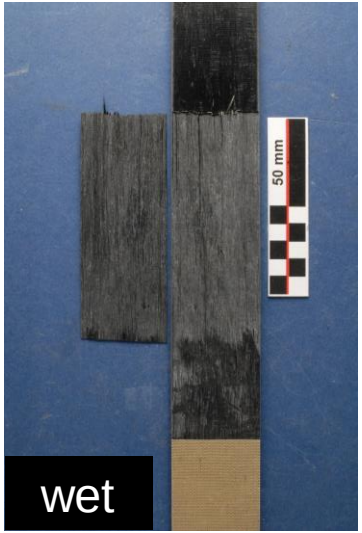

Results

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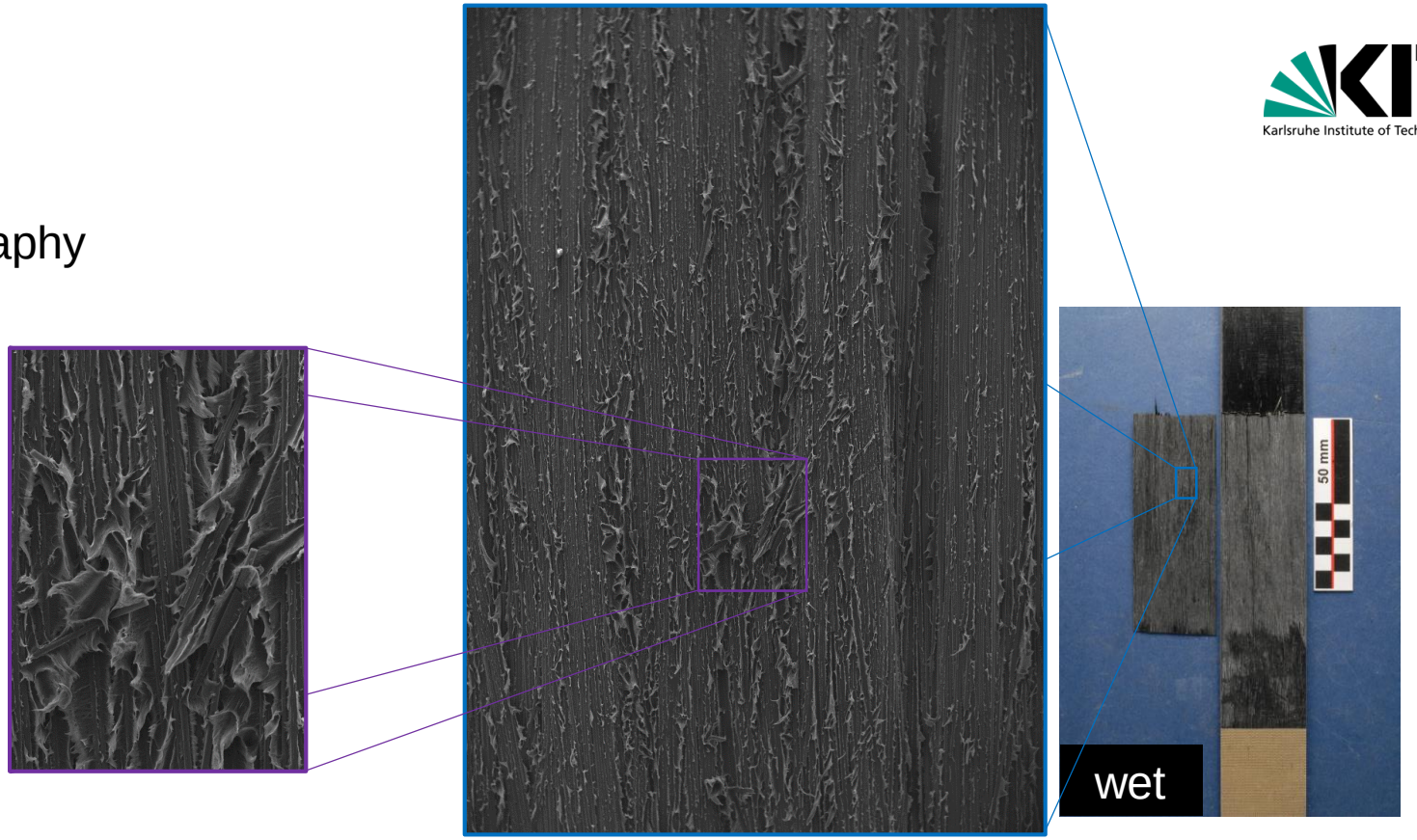
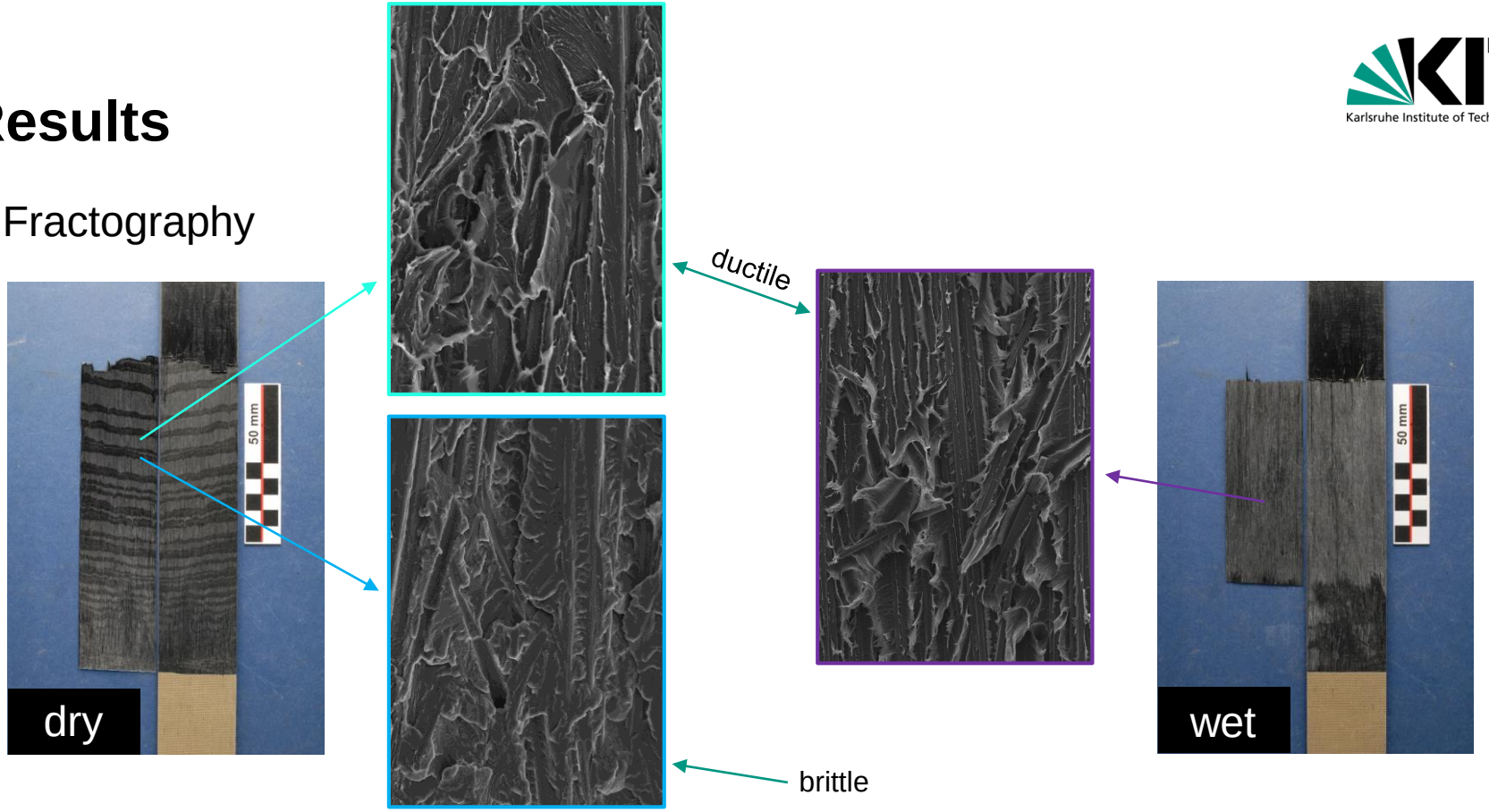


Results

- Fractography

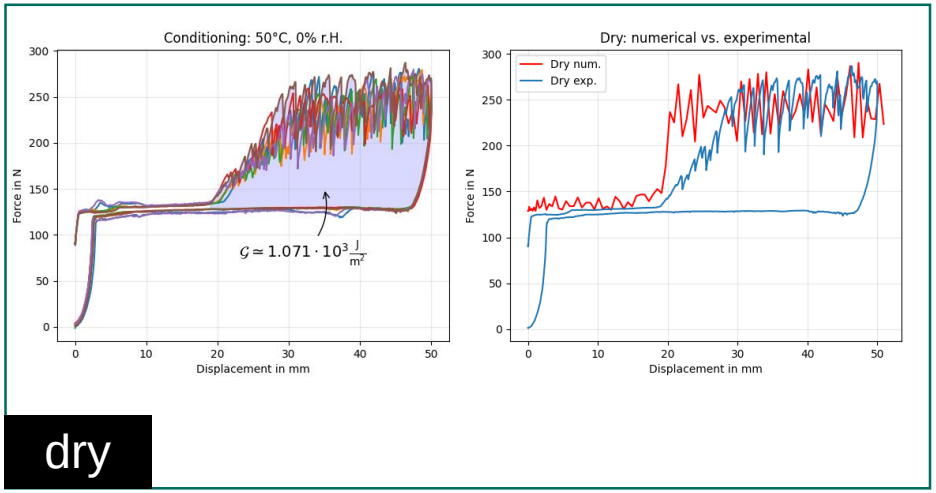


Results

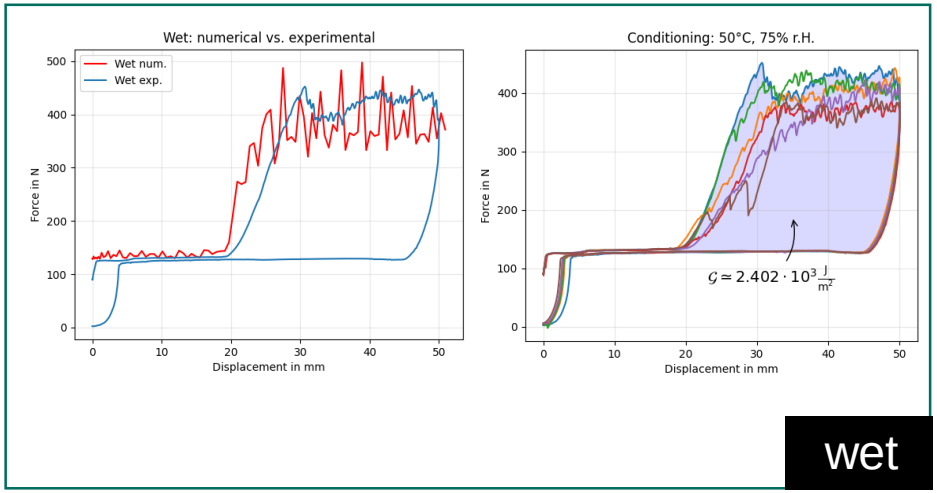
- Experimental Findings:
  - Dry interface has lower fracture toughness
    - Alternating ductile/brittle crack propagation leads to lower energy absorption when crack propagates
    - Magnitude of oscillation is increased
  - Hypothesis: water absorption allows for enhanced polymer chain mobility and increases elongation at failure, thus ductile fracture is enhanced

Results

- Numerical (work in progress):



dry



wet

Motivation → Method → Results → Outlook

Results

- Numerical Findings:
  - Energy release rate from experiment can be used in CZ to capture effective behavior
    - Magnitude of oscillations still challenging
  - Confirmation that energy release rate is significantly greater with water absorption

Outlook

- Experimental:
  - Conduct more experiment for different conditioning states
    - Does more water always lead to a greater energy release rate?
- Numerical:
  - Achieve better fitting by conducting numerical studies on the effects of…
    - Mesh size
    - Damage initiation parameter
    - Material parameters of Co and DiCo
    - …

References

[1] Kärger, Hrymak, Henning, Weidenmann, Böhlke, Wood - Continuous-Discontinuous Fiber-Reinforced Polymers - An Integrated Engineering Approach. Carl Hanser *Verlag*, 2020

[2] Scheuring et al. (2022) – Comparison of influence of hydrothermal aging on the mechanical properties glass and carbon long fiber-reinforced polyamide 6

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[4] Schober (2019) – On the Characterization and Modeling of Interfaces in Fiber Reinforced Polymer Structures

Thank you for your attention!

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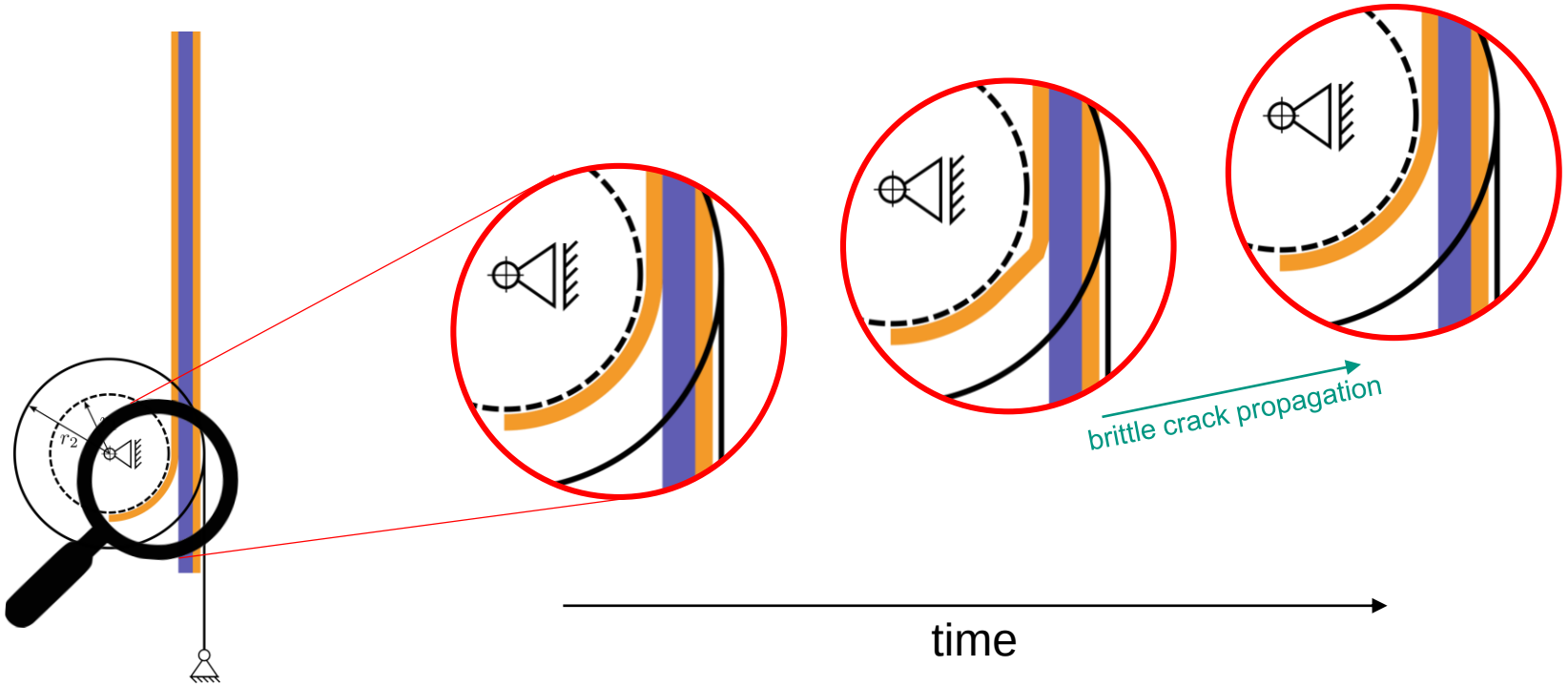
Members of the International Research and Training Group GRK 2078

Ductile/brittle alternation



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