Investigation of Interlaminar Fracture Mechanics of FRP using Digital Image Correlation

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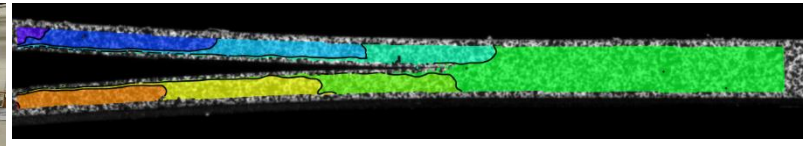
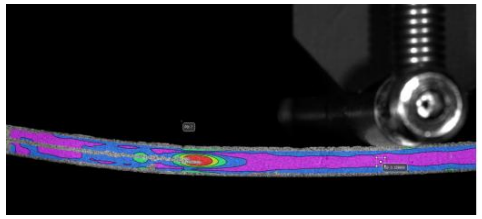
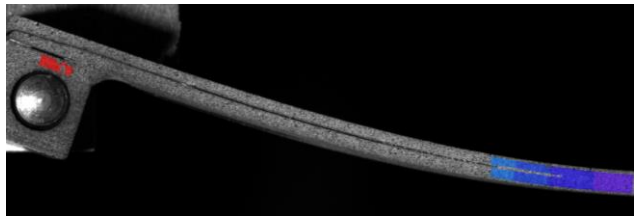
Lecture/Workshop @ KIT, April 23rd - 26th, 2019

Center for Automotive Lightweighting (NCAL)

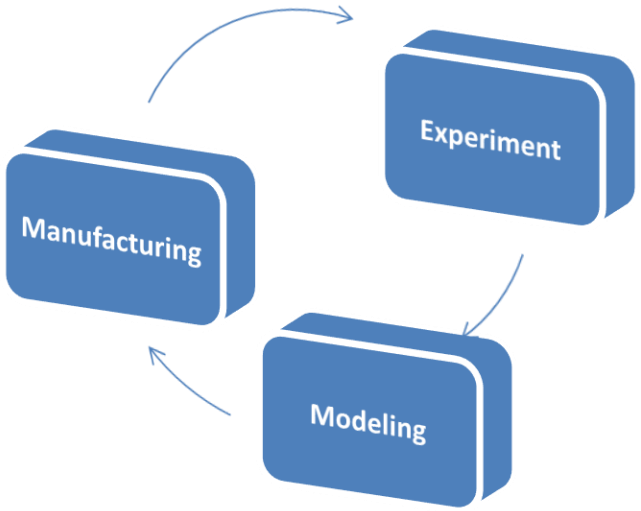





NIST Center for Automotive Lightweighting

Concept & Aims of Lecture/Workshop

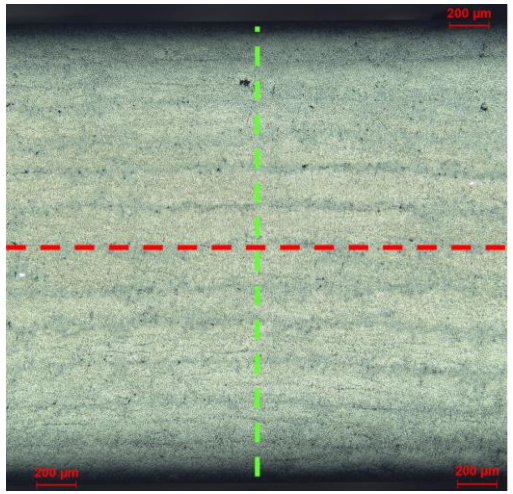
- **Interdisciplinary lecture/workshop:**
  - 4 days: Tuesday through Friday
  - Theoretical and experimental parts, tutorials
  - Handouts in English will be provided (‘fill in the gaps’)
  - Presentation in German (or English, if preferred)
- **Theoretical parts:**
  - Computational material science and manufacturing as motivation (‘Why testing?’)
  - Background/mechanics of fracture experiments
  - Different types of experiments for fracture testing on prototypical UD composites
  - Design of experiments (‘Everything is of interest but what/how much data is actually needed?’)
  - Experimental setup (MTS and DIC)
  - Data analysis and reduction
  - Sensitivity analysis (‘3 x same type of test vs. 1 test with 3 different views?’)
- **Experimental parts and tutorial – knowledge transfer:**
  - Prototypical material: CFRP – UD and/or fiber reinforced material of interest
  - Design of experiments:
    - Selected types of experiments
    - Experimental setup (MTS and DIC)
  - Data analysis and reduction
  - Sensitivity analysis
  - Discussion of results
- **Aims:**
  1. Interdisciplinary view on experimental testing
  2. Challenges in mechanical fracture testing
  3. Data interpretation (sensitivity analysis)

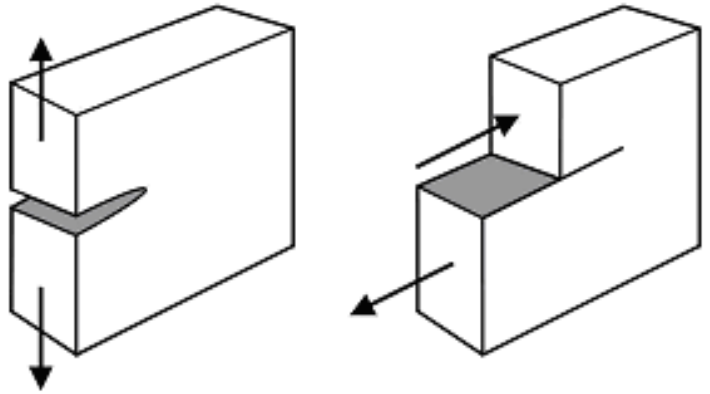
Motivation & Outline of Lecture/Workshop

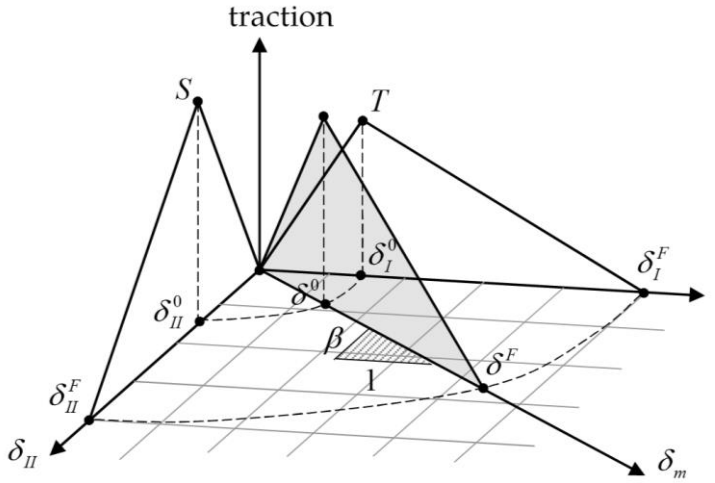


1. **Models** need 'data' for crash simulation!
   - How do models look like? What data is needed?
2. What is the appropriate **Experiment**?
   - What test method(s) provide the data needed?
3. Enhanced **Manufacturing** of complex composites
   - Restrictions/necessary improvements for the experiment?

UD: Interlaminar Fracture Testing: Mode I and Mode II





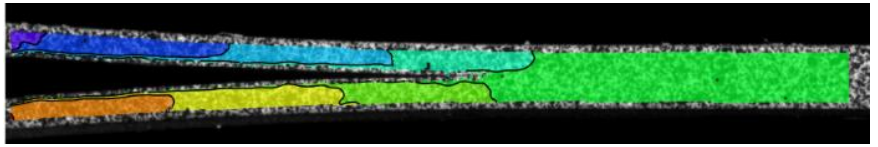


→ **Full description for cohesive zone modeling via traction separation laws**

Agenda 1-2

- **Tuesday, 23.04. (5.5 h)**
  - Introduction:
    - Matthias Merzkirch & NIST
    - Audience
  - Motivation:
    - Automotive & aerospace
    - Lightweight aspect
    - Computational material science: Cohesive Zone Models & Traction Separation Laws
  - Digital Image Correlation - A short introduction:
    - Patterning
    - Principle of 2D and stereo DIC
    - Calibration
    - Examples
  - Recommended literature
  - Discussion, design and planning of experiments:
    - Interdisciplinary needs and expectations

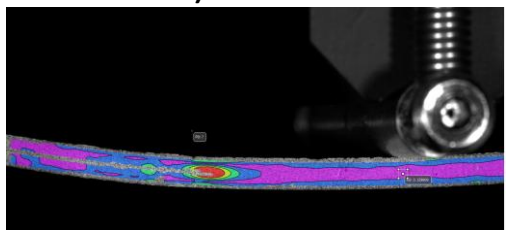
- **Wednesday, 24.04. (5.5 h)**
  - Fracture testing of fibrous composites: overview
  - Crack Tip Tracing with DIC
  - Mode I testing (double cantilever beam flexure):
    - Principle
    - Photomechanics
  - Fracture toughness G_I acc. to:
    - ASTM
    - DIN
    - ISO
    - Non-standardized methods



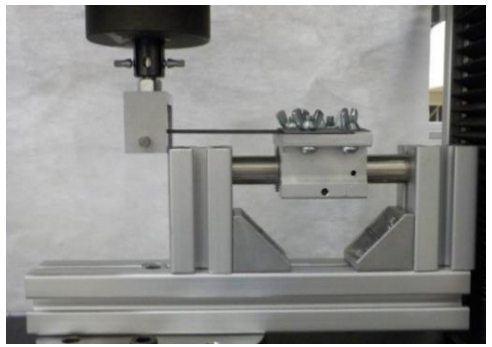
  - Sensitivity analysis
  - Restrictions and challenges
  - Through thickness properties:
    - Photomechanics & analytical solutions for traction separation law
  - Tutorial

Agenda 3-4

- **Thursday, 25.04. (5.5 h)**
  - Mechanics of flexural testing (3pt bending)
    - Shear stress and shear deformation
  - Mode II testing (3pt end-notched flexure):
    - Principle
    - Photomechanics



  - Fracture toughness G_{II} acc. to:
    - ASTM & DIN
    - Non-standardized methods
  - Mode II testing (calibrated end-loaded split flexure):
    - Principle
    - Photomechanics
    - Fracture toughness G_{II}



  - Comparison types of tests
  - Restrictions and challenges
  - Photomechanics - Traction separation law
  - Tutorial

- **Friday, 26.04. (4.5 h)**
  - Discussion of results on fracture properties:
    - Mixed Mode behavior
    - Cohesive Zone Model & Traction Separation Laws
  - Comparison of Young's Moduli:
    - E_T From tensile test
    - Flexural testing
      - 3 pt
      - 4 pt
      - Double cantilever
      - End loaded split test (single cantilever)
  - Exam (1 h):
    - ECTS: 2
  - Evaluation