*MAT_4A_MICROMEC –
Generating Material Card and Considering Fiber Orientation

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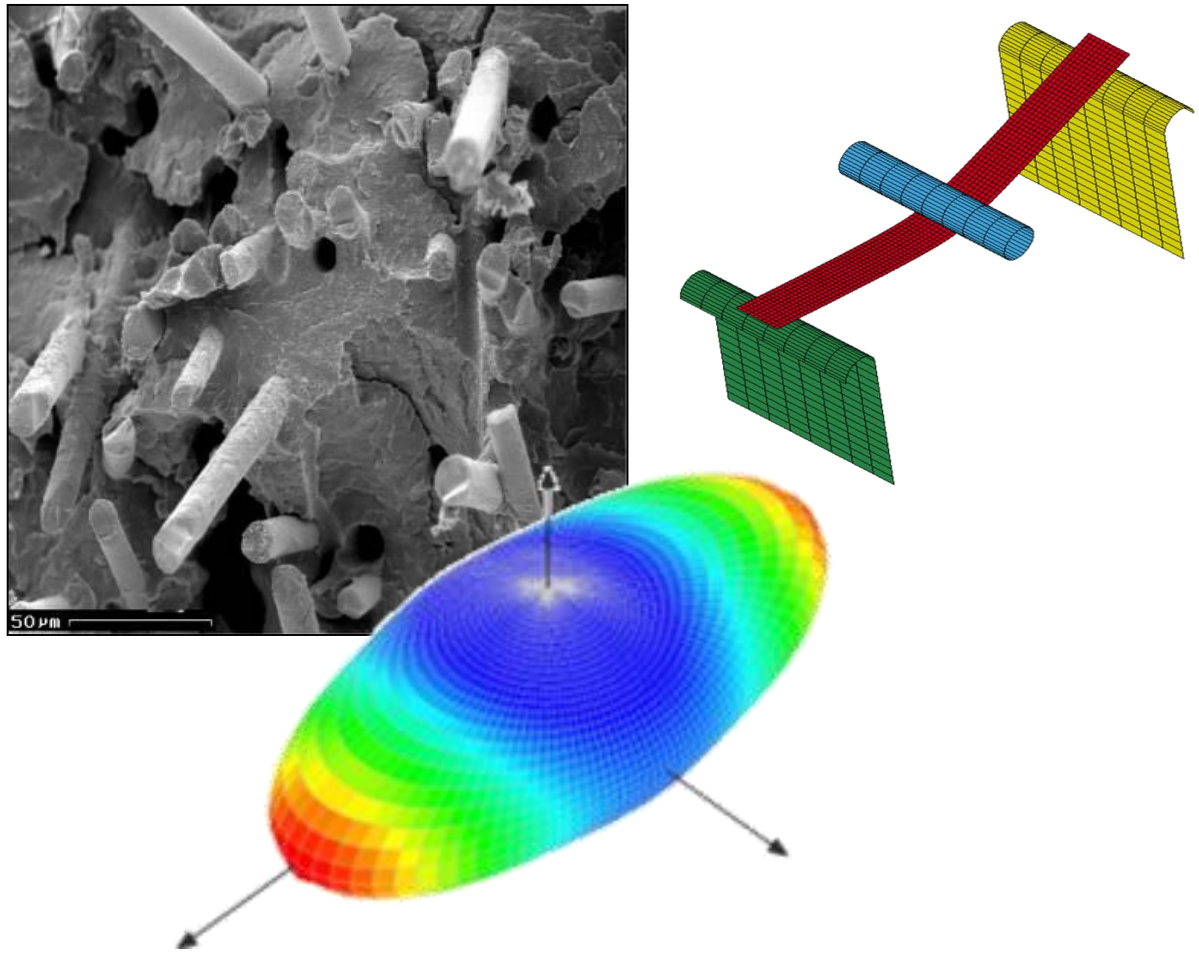
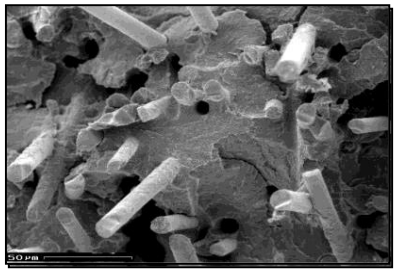
Bamberg 15-17.10.2018

Outline

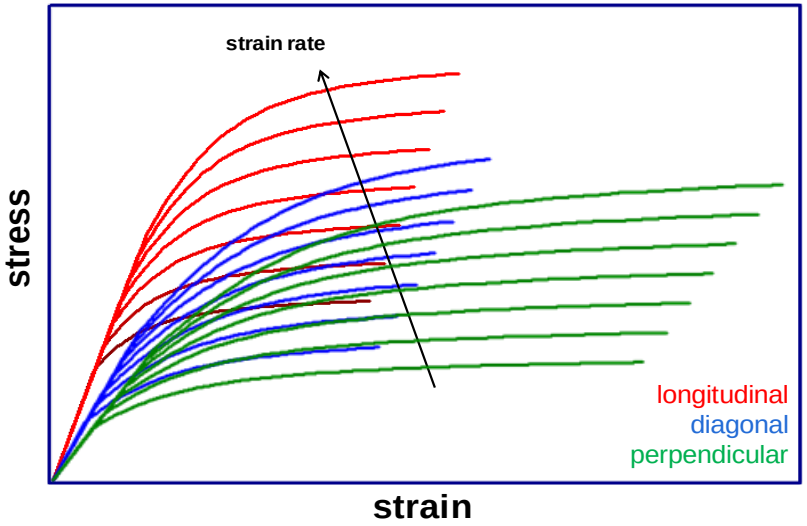
- Introduction 4a products
- Motivation
- How to get *MAT_215 ?
- Injection Molding
  - Process simulation
  - Mapping
- Summary & Outlook

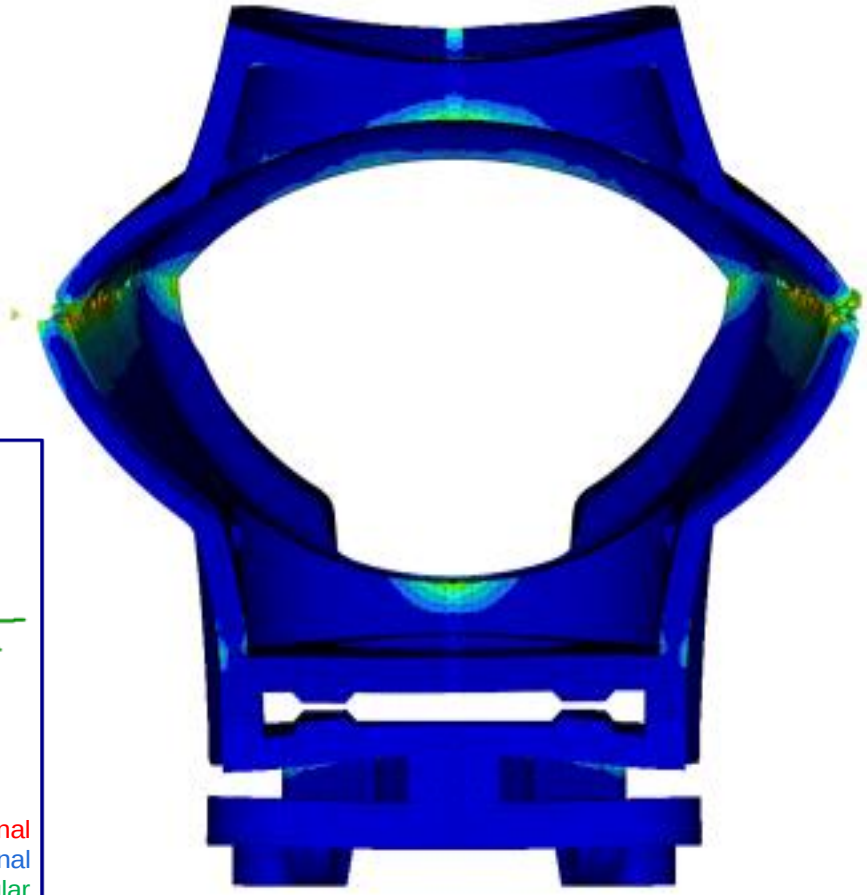


Motivation – current standard



*MAT_024



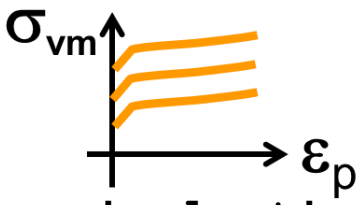
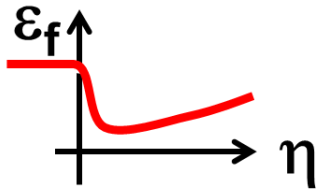
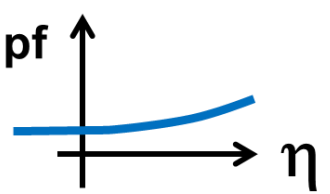


See more:

S. Seichter et al (Hirtenberger) – Influence Parameters on the Behaviour of Short Fibre Reinforced Polyamide with Focus on Humidity and Integrative Simulation. German LS DYNA Forum 2018

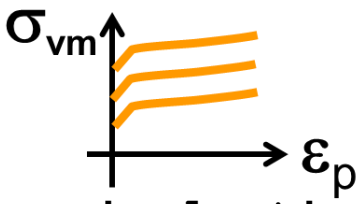
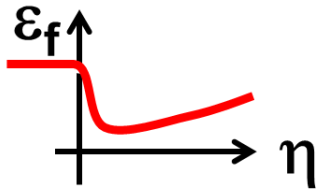
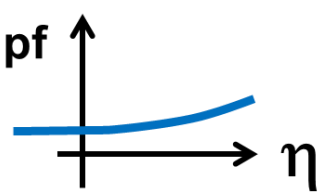
Motivation – Status different materials - **MAT_215*

Application Notes
europ. LS-DYNA conference Salzburg 2017

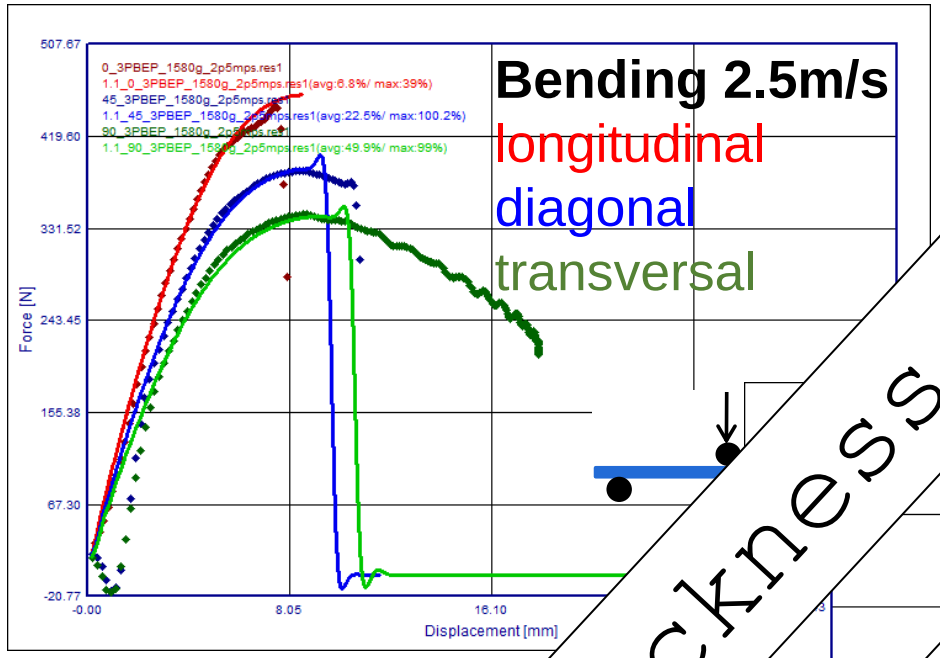
	Fiber	Hardening  inelastic deformation	Damage Initiation  initial Failure	Damage Evolution  Failure Evolution
PP LGF30	LFRT l/d ~ 50	✓	✓	~
PBT GF30	SFRT l/d ~ 20	✓	✓	✓
PA6 GF30 impact modified	SFRT l/d ~ 30	✓	~	✗

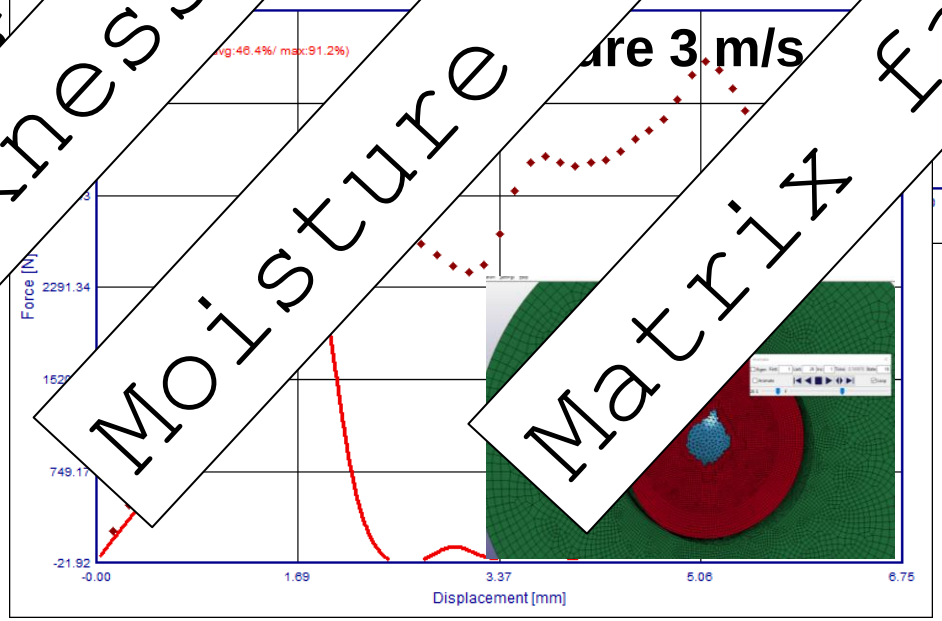
Motivation – Status different materials - **MAT_215*

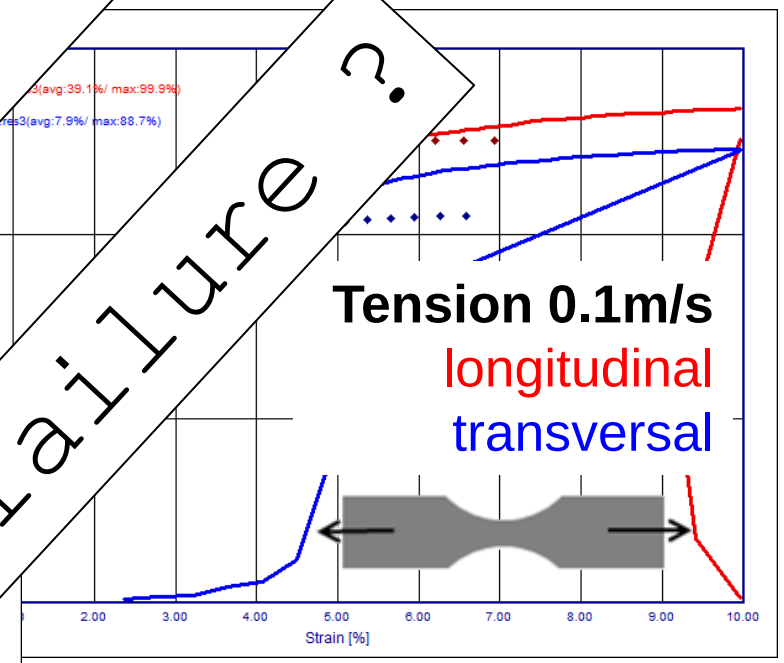
Application Notes
[int. LS-DYNA conference Detroit 2018]

	Fiber	Hardening  inelastic deformation	Damage Initiation  initial Failure	Damage Evolution  Failure Evolution
PP LGF30	LFRT l/d ~ 50	✓	✓	✓
PBT GF30	SFRT l/d ~ 20	✓	✓	✓
PA6 GF30 impact modified	SFRT l/d ~ 30	✓	~	✗

Motivation – Status PA6 HI GF30





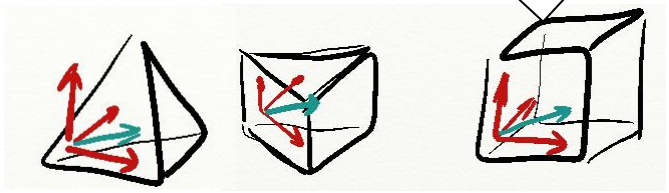


Thickness (4mm) ?

Moisture content ?

Matrix failure ?

···· averaged test curves
— result of simulation



*MAT_215 - KEYWORD

header

composite

fiber

matrix

```
$=========================================================================
*MAT_4A_MICROMEC
$01     mid      mmopt       bupd         --         --      failm      failf     NUMINT
   1000000        1.0       0.01                               0.         0.      -65.
$02    aopt       macf         xp         yp         zp         a1         a2         a3
          0          0        0.0        0.0        0.0        1.0        0.0        0.0
$03      v1         v2         v3         d1         d2         d3       beta         --
         0.0        0.0        0.0        0.0        0.0        1.0        45.
$04     fvf         --         fl         fd         --        a11        a22         --
        .115                   53.        1.0                   .7        .25
$05     rof         el         et        glt       prtl       prtt         --         --
2.5899e-09    70000.     70000.     28759.      0.217      0.217
$06      xt         --         --         --         --         --     SLIMXT     NCYRED
     2800.                                                           0.01         10
$07     rom          e         pr         --         --         --         --         --
  1.09e-09     1500.        0.3
$08   sigyt       etant         --         --       eps0          c
$09    LCST         --         --         --       LCDI       UPF
   1000000                                       1000020  -1000026
$=========================================================================
```

options
direction

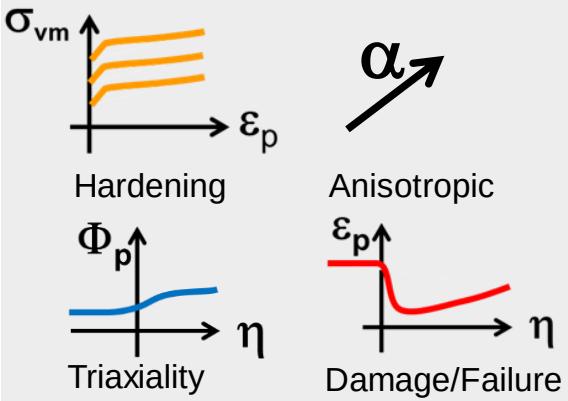
definition

transversal i. elasticity
failure

isotropic elasticity
viscoplasticty
damage

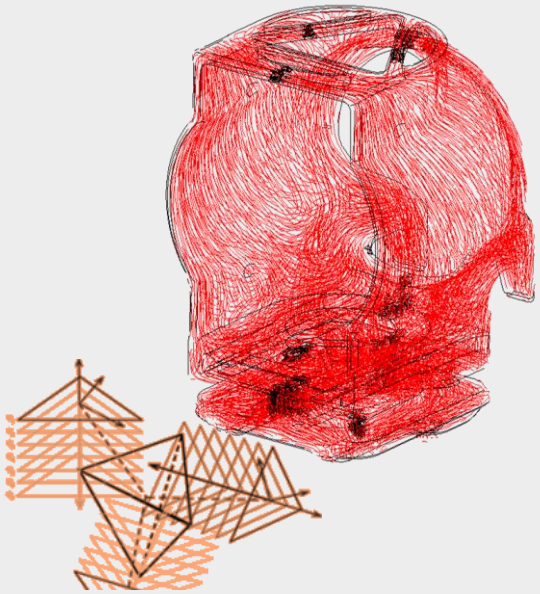
How to get **MAT_215* ?

VALIMAT



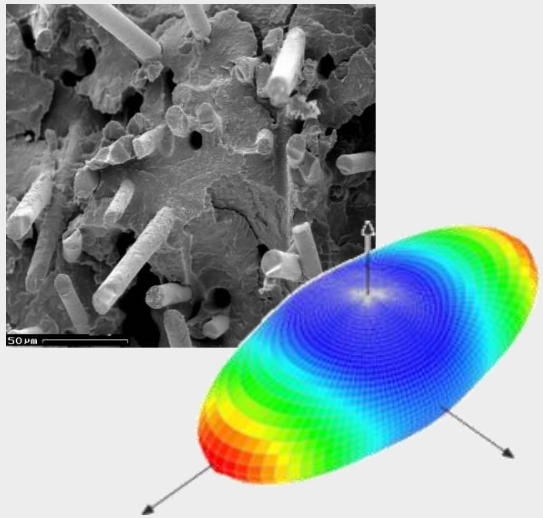
from test to validated material cards

FIBERMAP



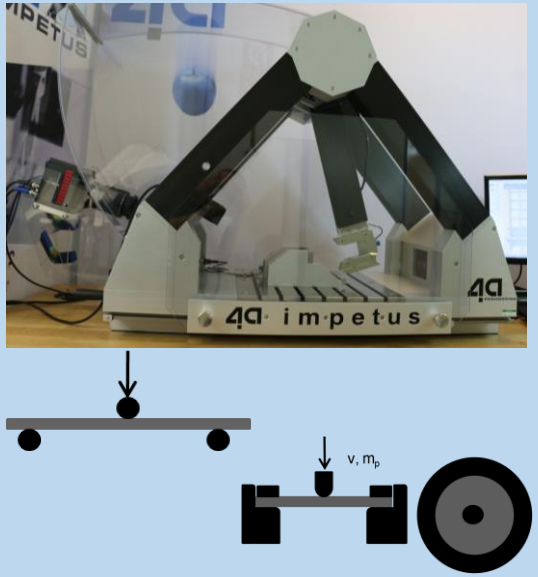
individual mapping process information

MICROMEC



3D anisotropic material cards

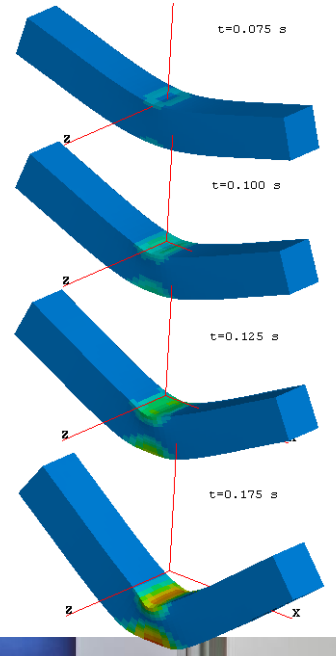
IMPETUS

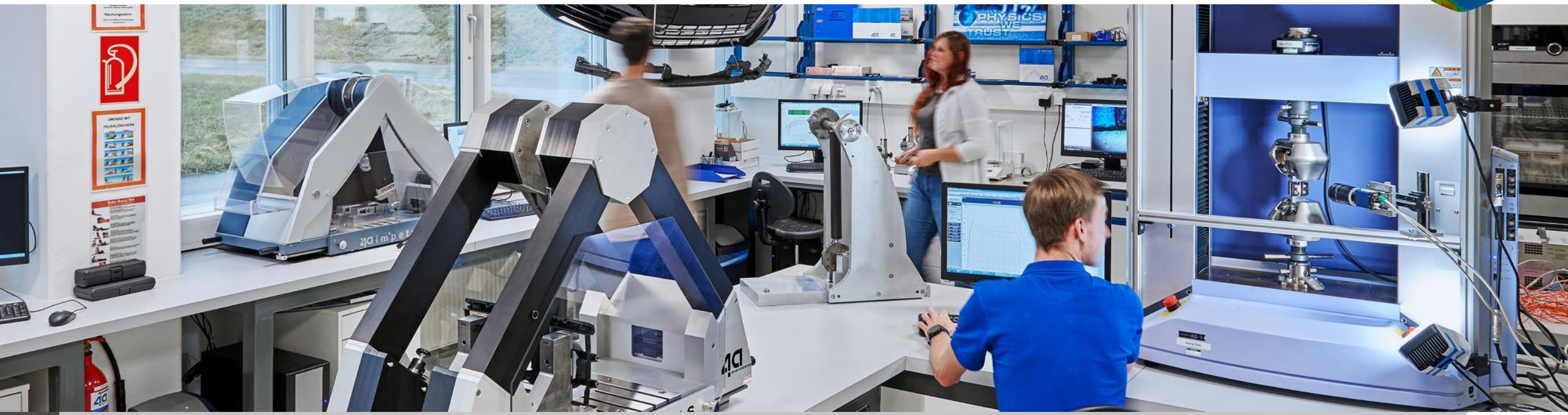


efficient dynamic testing

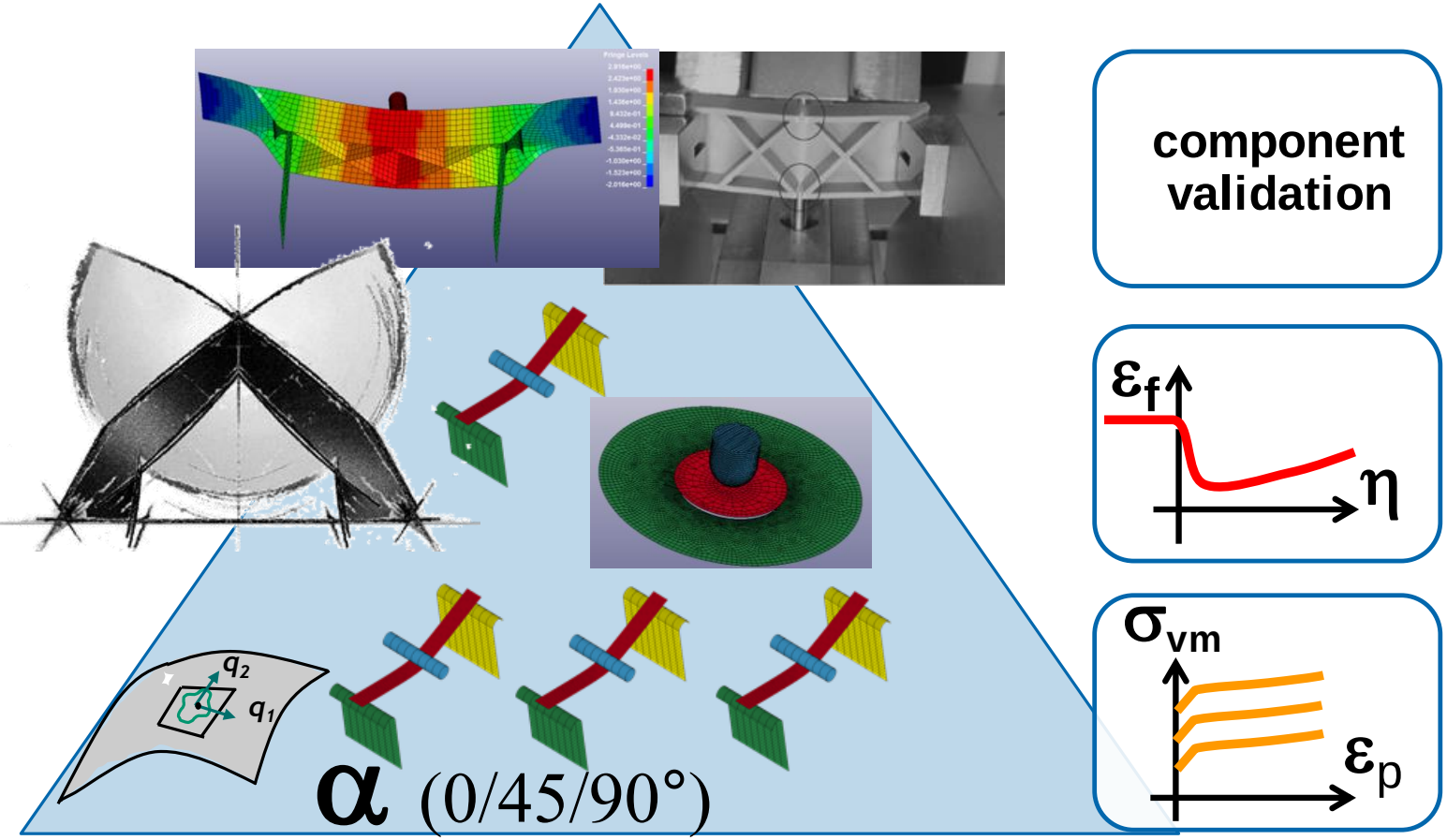
How to get **MAT_215* ?

- efficient high-dynamic testing
- dynamic material behaviour
- plastics, foams, composites, …
- **validated material cards ready to use for your crash-simulation**

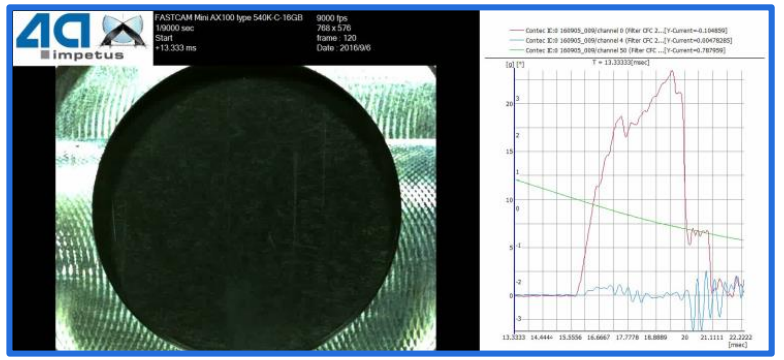


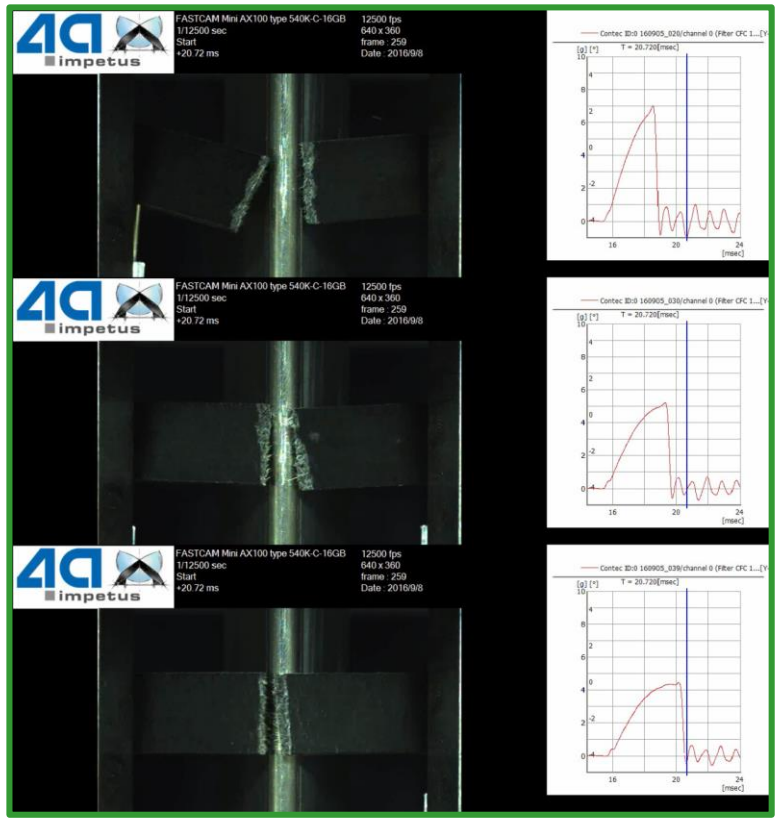


How to get **MAT_215* ?



component validation





See more: P Reithofer, et.al., Versagen von faserverstärkten Kunststoffen bei dynamischer Beanspruchung, 4a Technologietag -2017

How to get **MAT_215* ?

fiber

- mechanical properties
- fiber content
- aspect ratio
- fiber orientation

literature

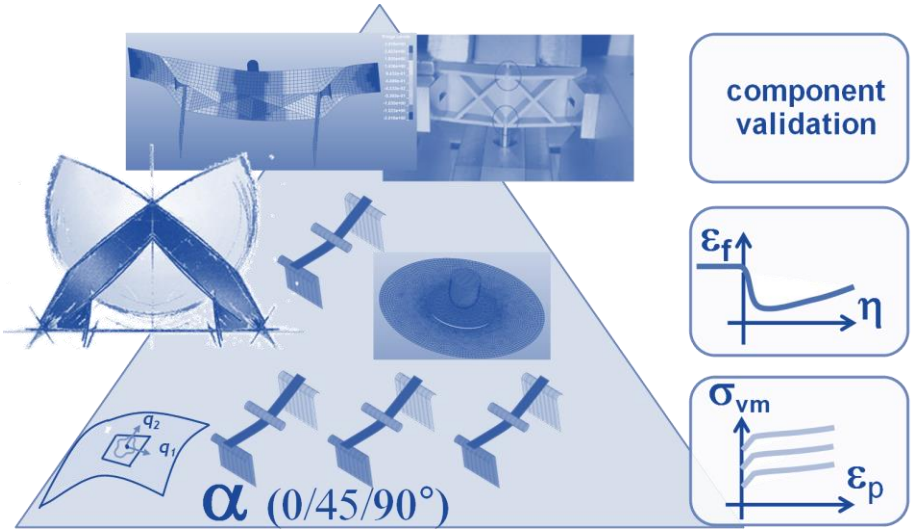
engineering judgement

tests (µCT, …)

matrix

- pseudo mechanical properties
  - yield
  - hardening
  - failure

REVERSE ENG.



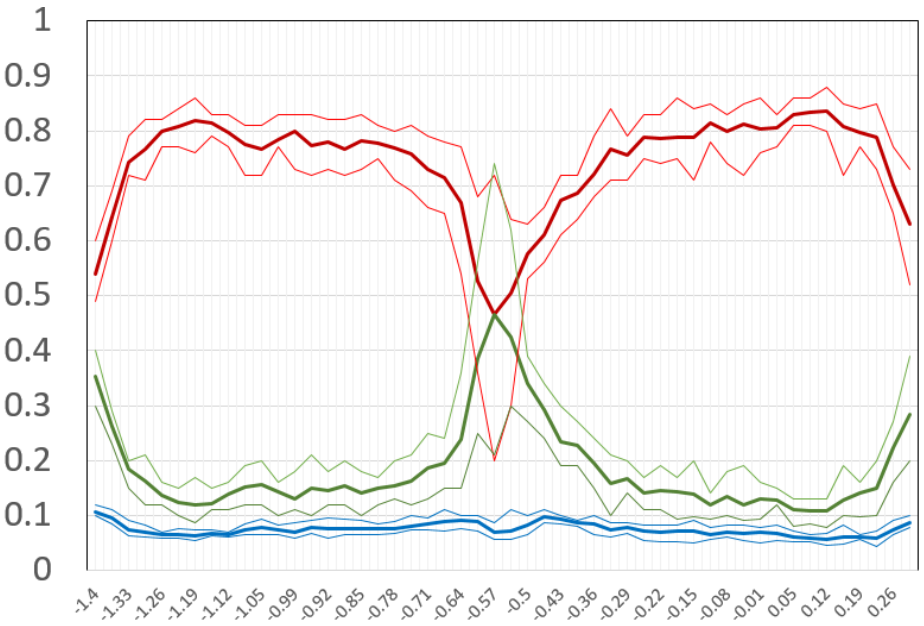
tests

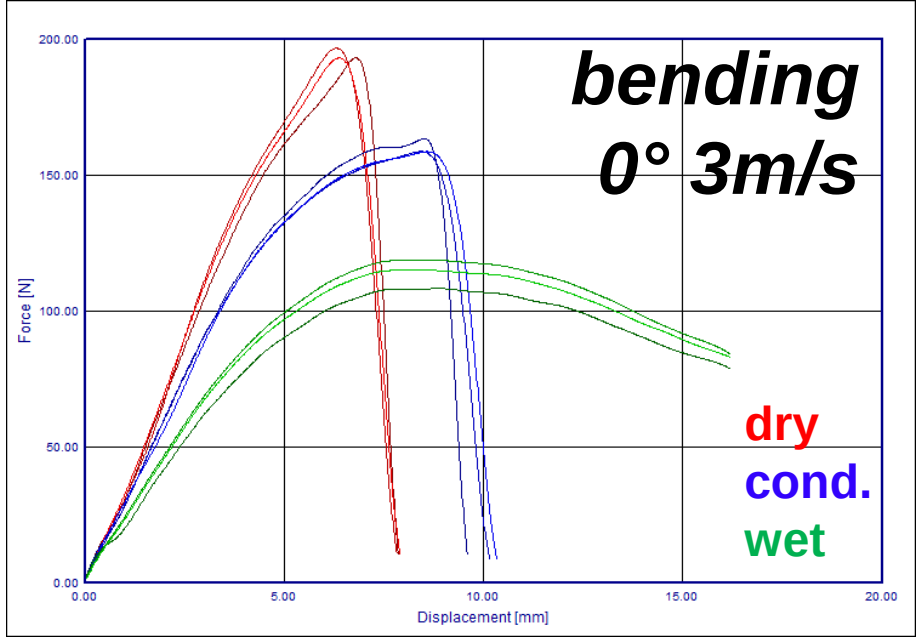
- bending and/or tensile
  - testing in different directions 0°, 30° (45°), 90° sample orientation
- uniaxial and biaxial
- static and dynamic

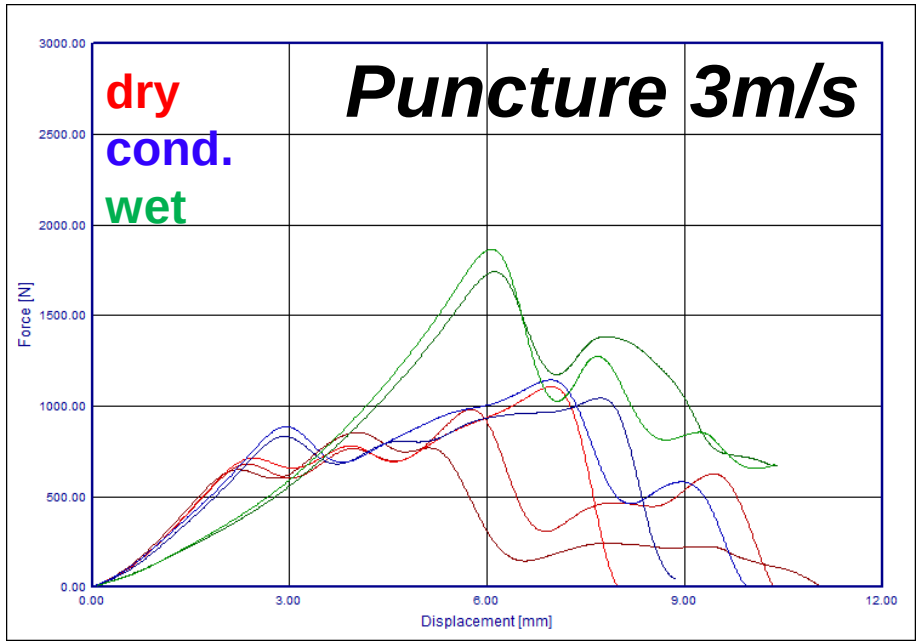
How to get **MAT_215 – case study PA6 GF30 I*

Provided by consortium (PCCL, HILTI, Hirtenberger)

- plaques for puncture tests
- bending samples (0°, ~30°, 90°)
- different moisture contents (dry, cond., wet)
- µCT measurements



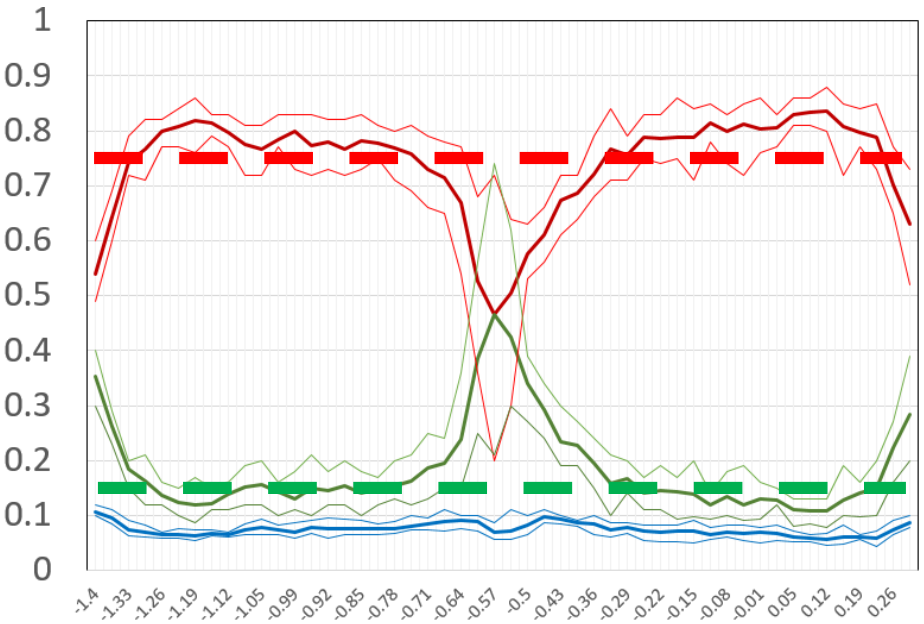


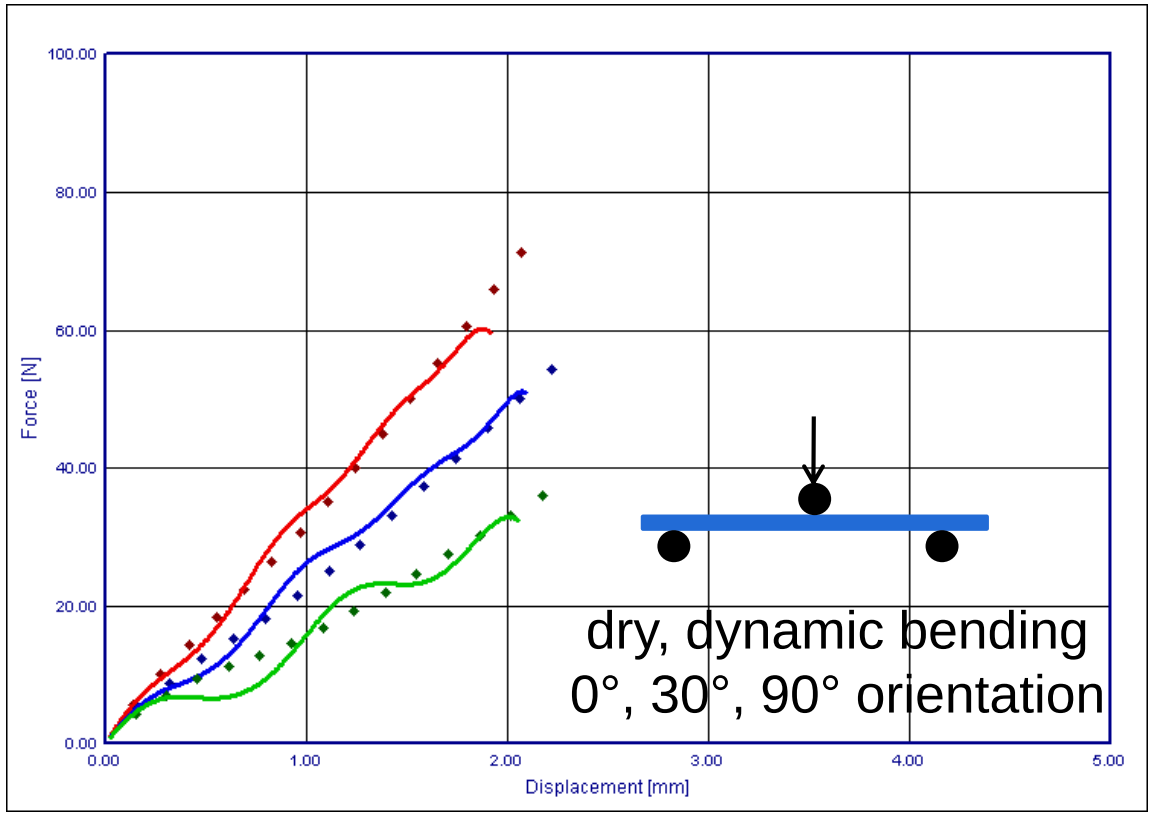


How to get **MAT_215 – case study PA6 GF30 I*

1st step: set up the composite

- Fiber properties from literature
- Fiber content 30%wt → **-0,3**
- Aspect ratio typical for short fibers l/d=20
- µCT measurements → average

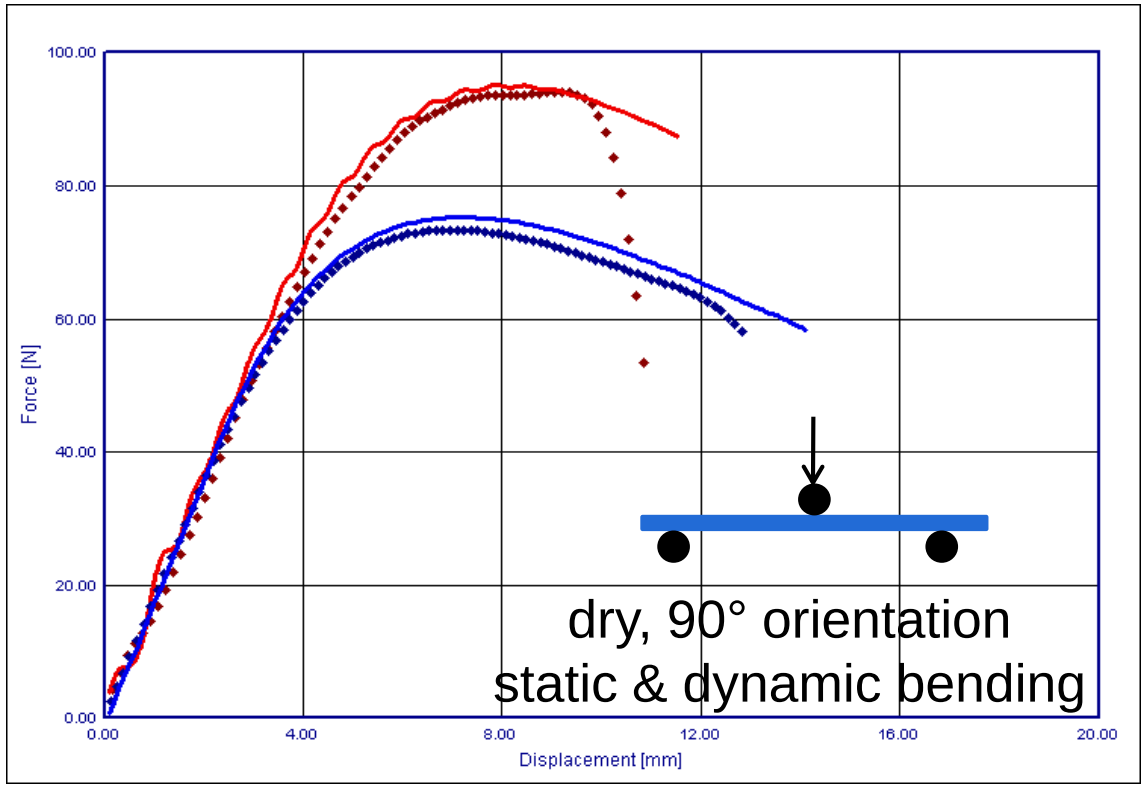




How to get **MAT_215 – case study PA6 GF30 I*

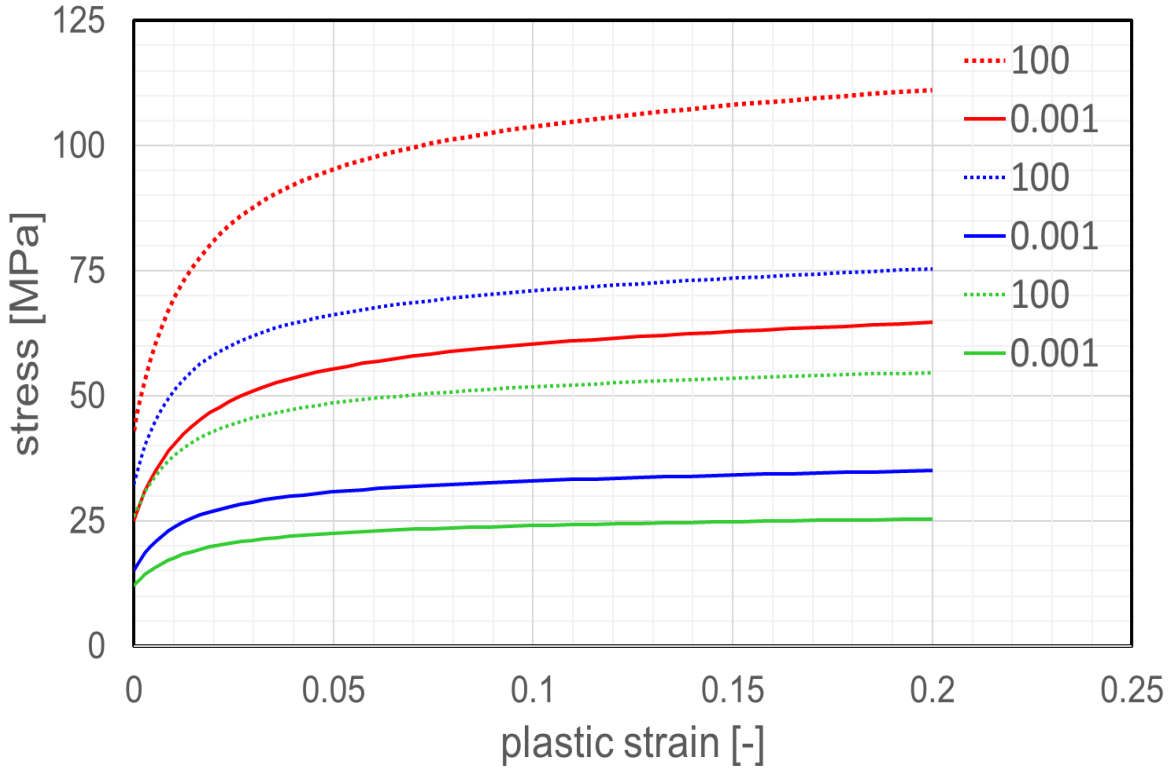
2nd step: matrix hardening

- parameter identification of hardening law



Matrix in dependence of moisture

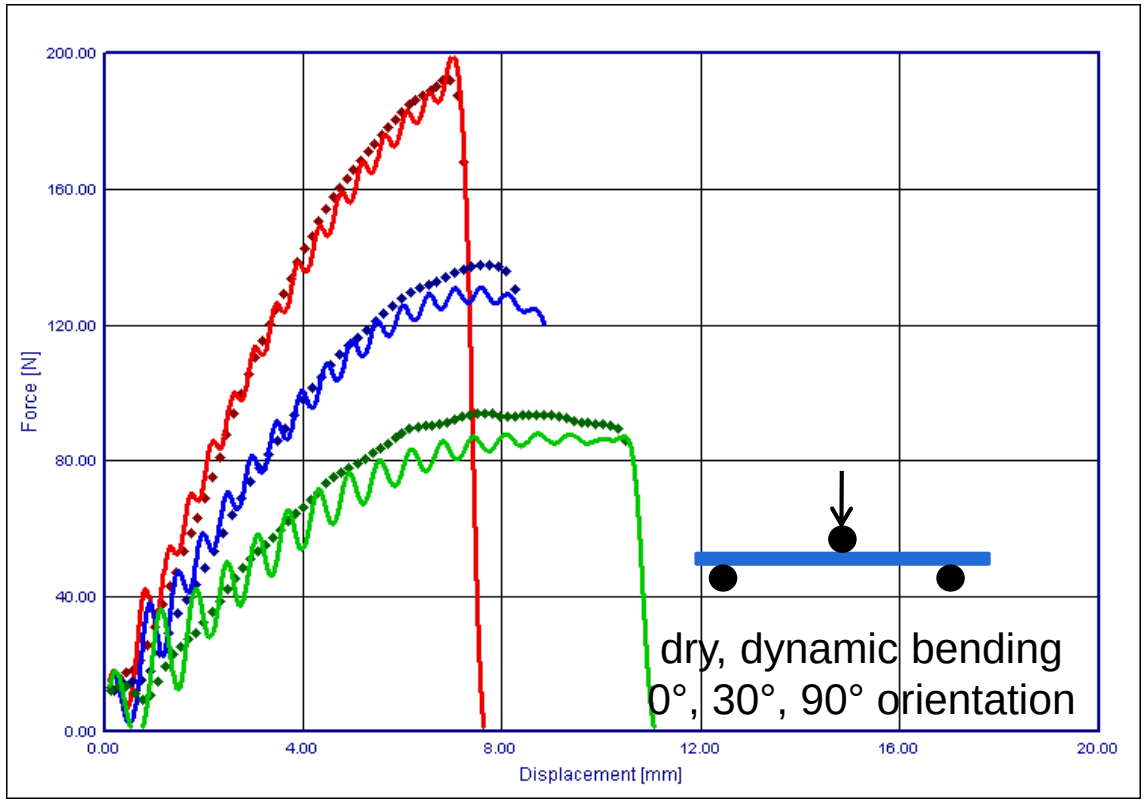
Young's Mod.	dry	cond.	wet
[MPa]	2500	1600	1450



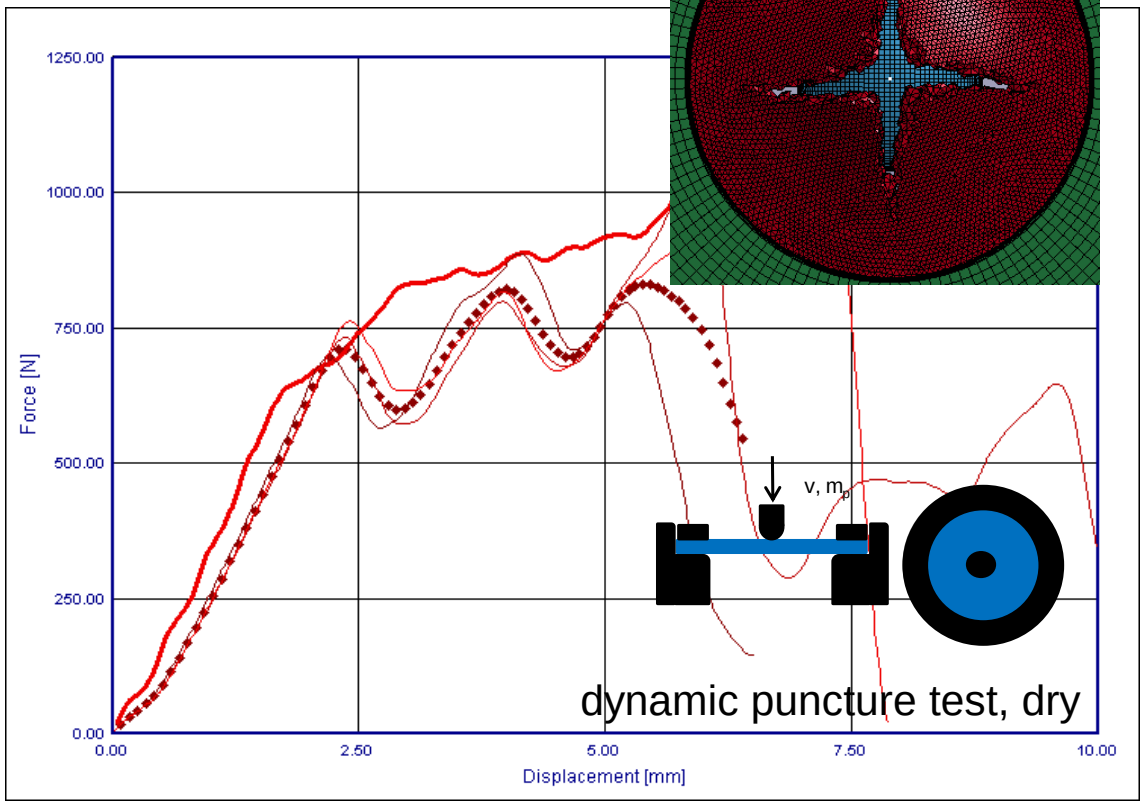
How to get **MAT_215 – case study PA6 GF30 I*

3rd step: validation on dynamic bending

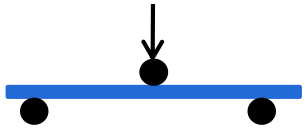
4th step: failure strains



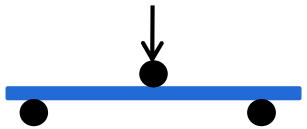
5th step: validation on dynamic puncture



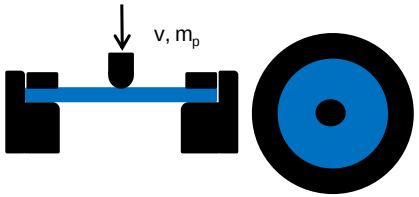
results – material characterization **without mapping**



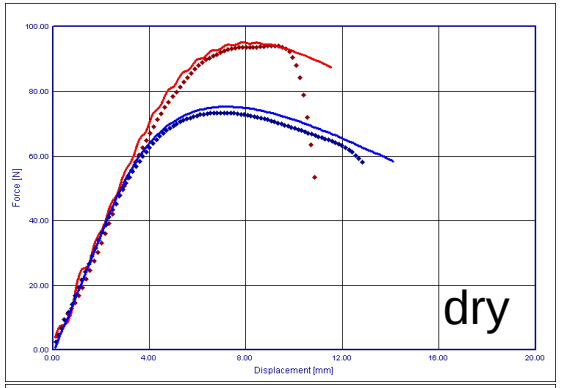
90° orientation
static & dynamic bending

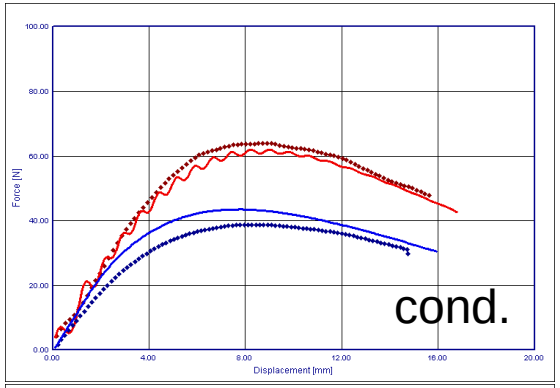


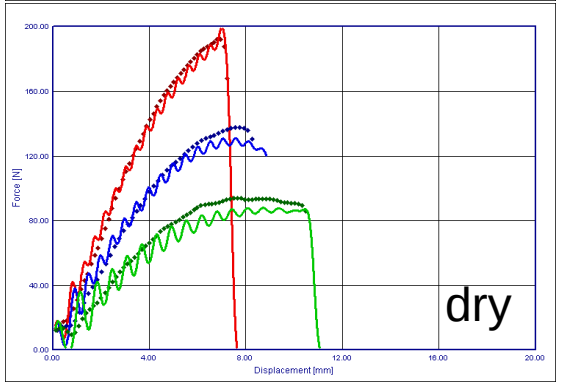
dynamic bending
0°, 30°, 90° orientation

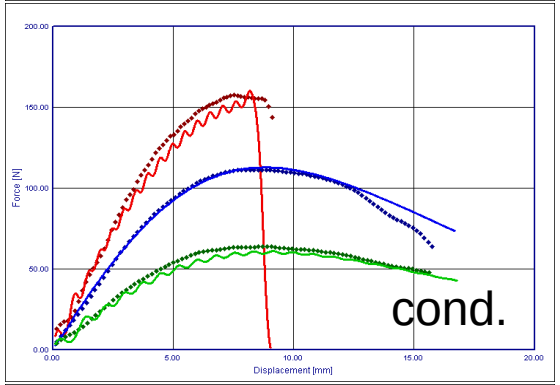


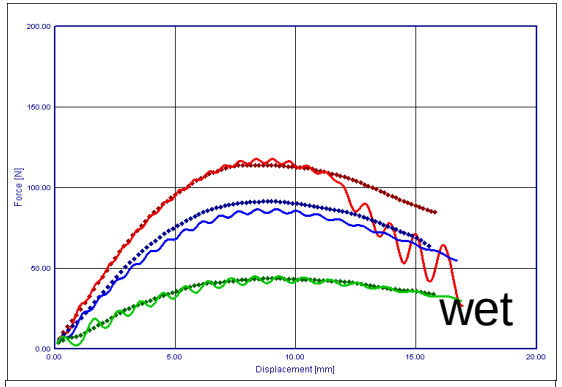
dynamic puncture test

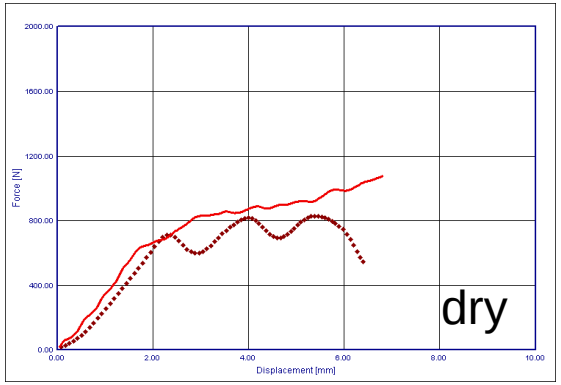


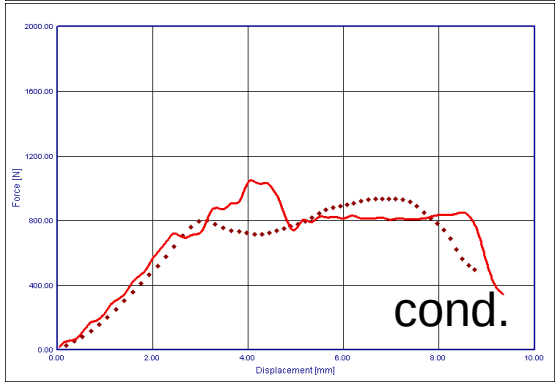


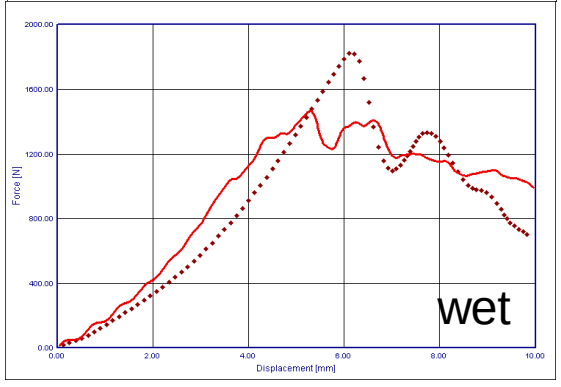


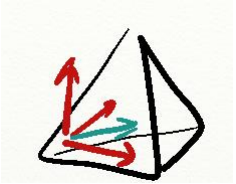












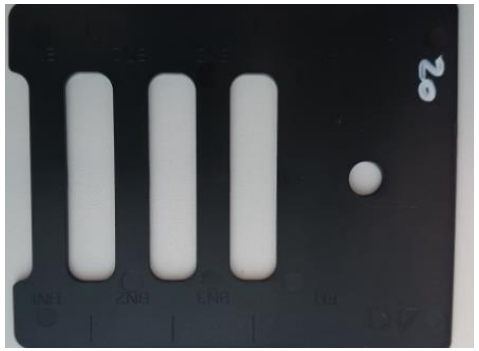
ELTYP4
0.5 mm

···· averaged test curves
— result of simulation

injection mold for material characterization

DOM & Wall thickness

Melt- & Weldlines



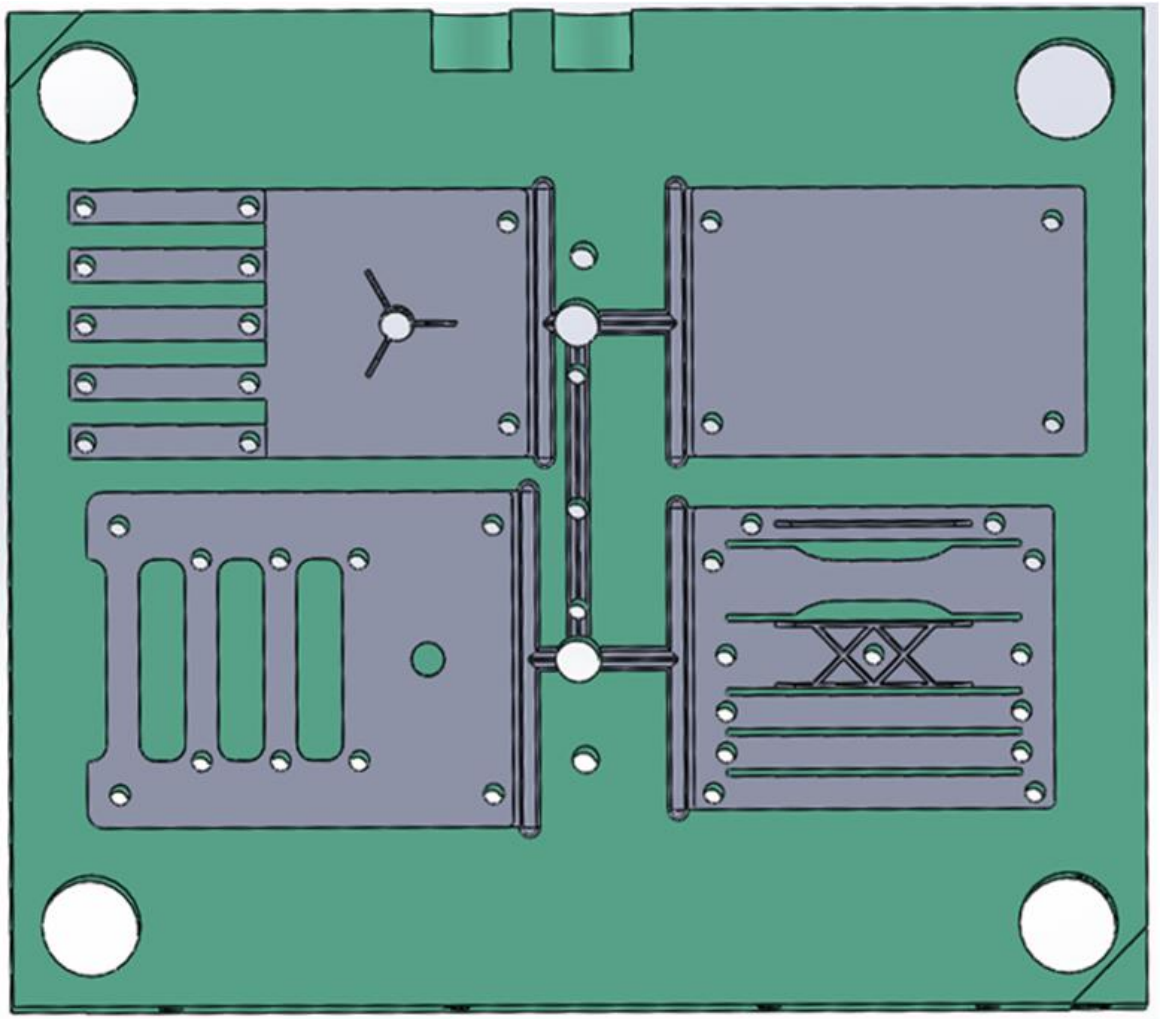
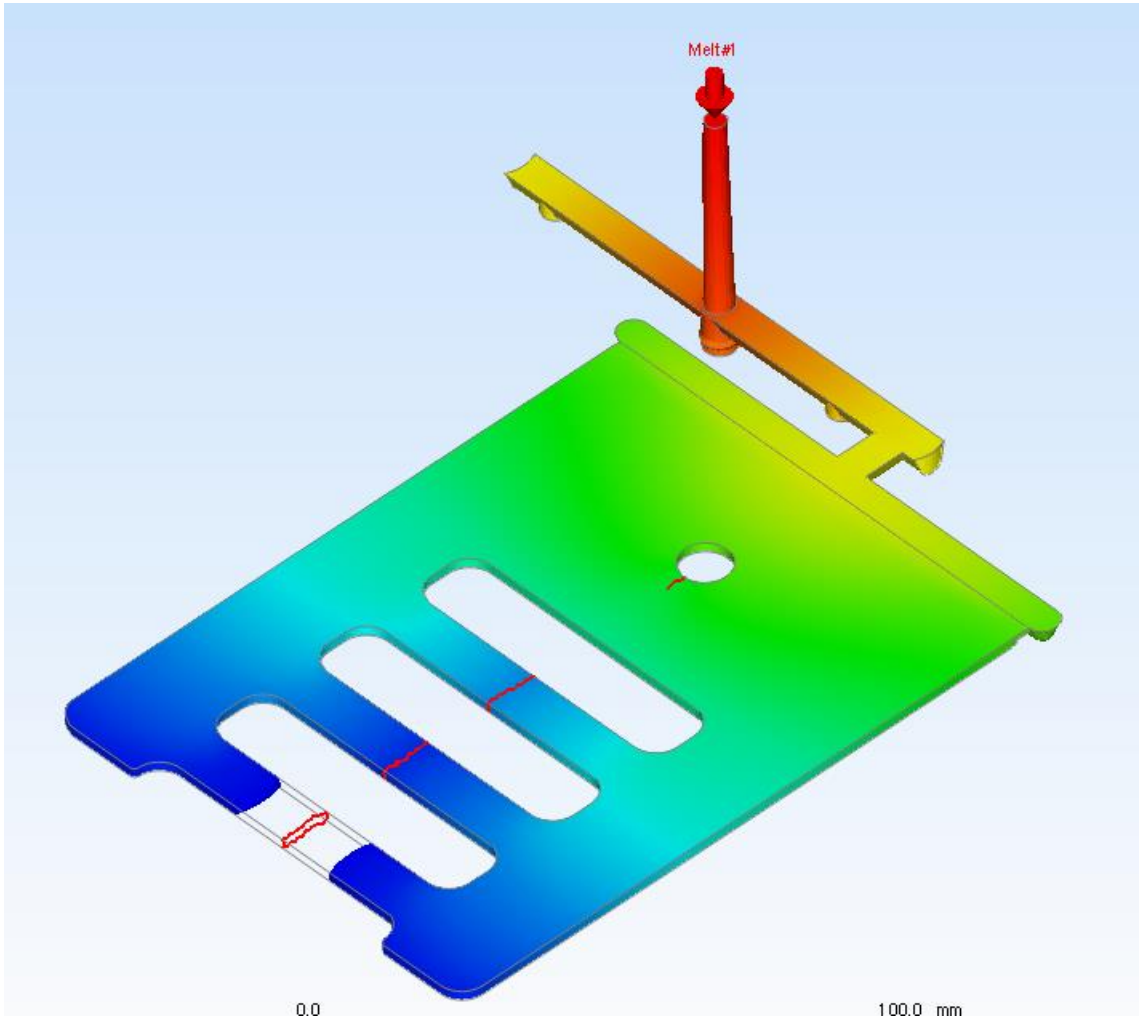
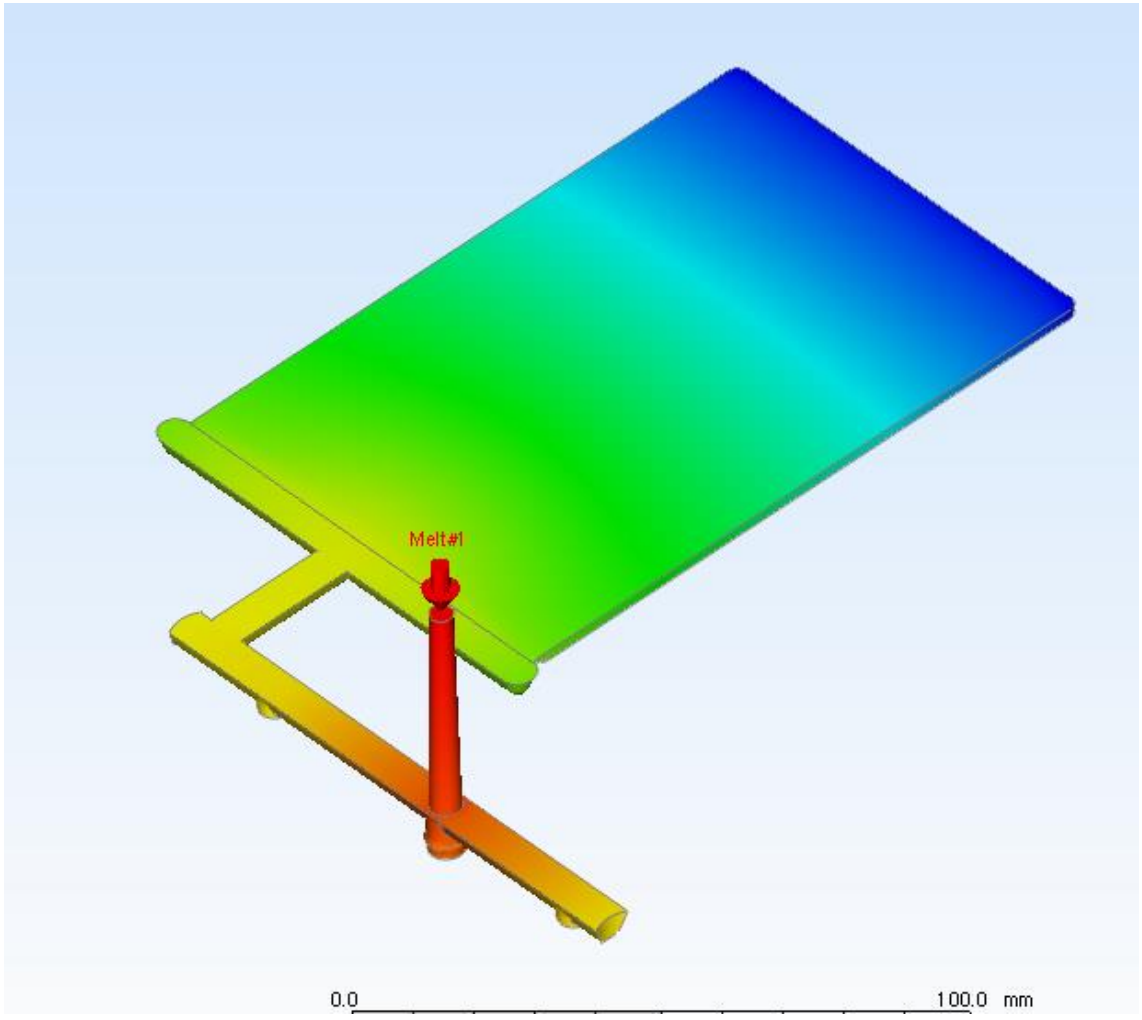


Plate 120 x 80 x 2 mm

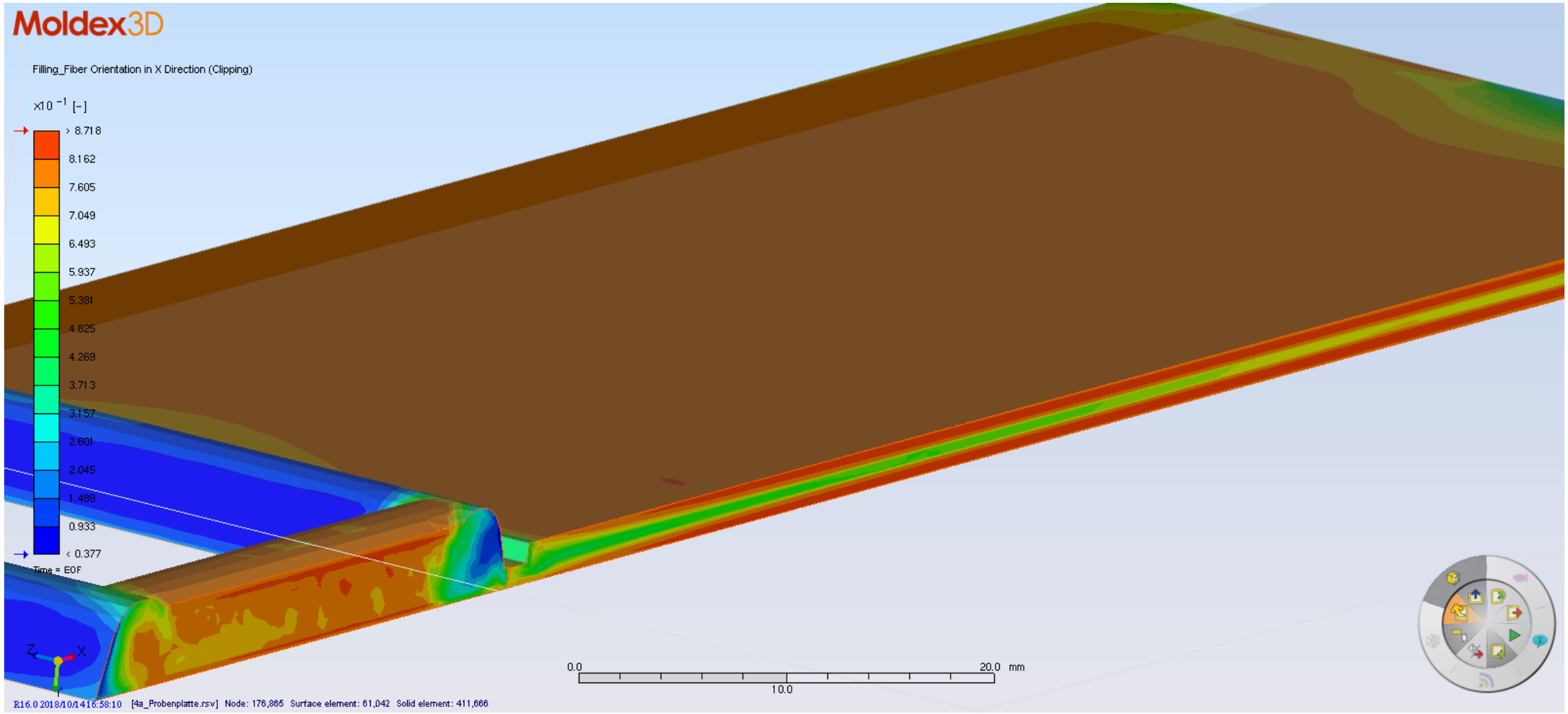
Multi-Specimen &
Rib & Component

injection mold – process simulation



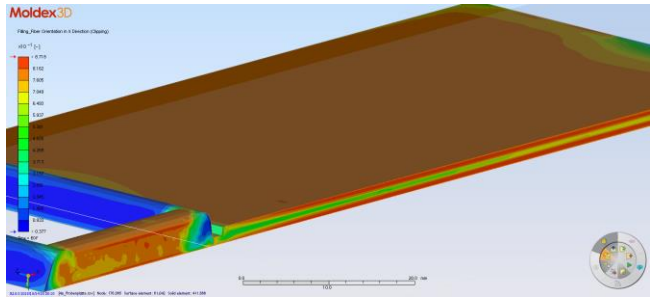


injection mold – process simulation fiber orientation



injection mold – process simulation & mapping

FIBERMAP



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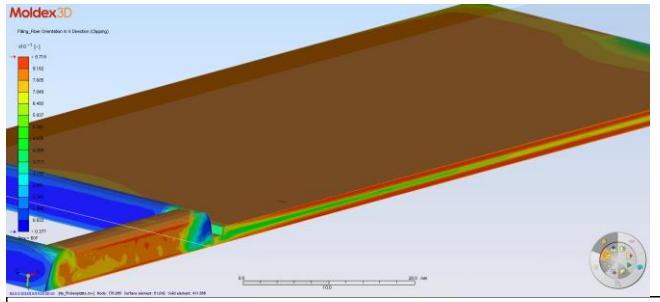
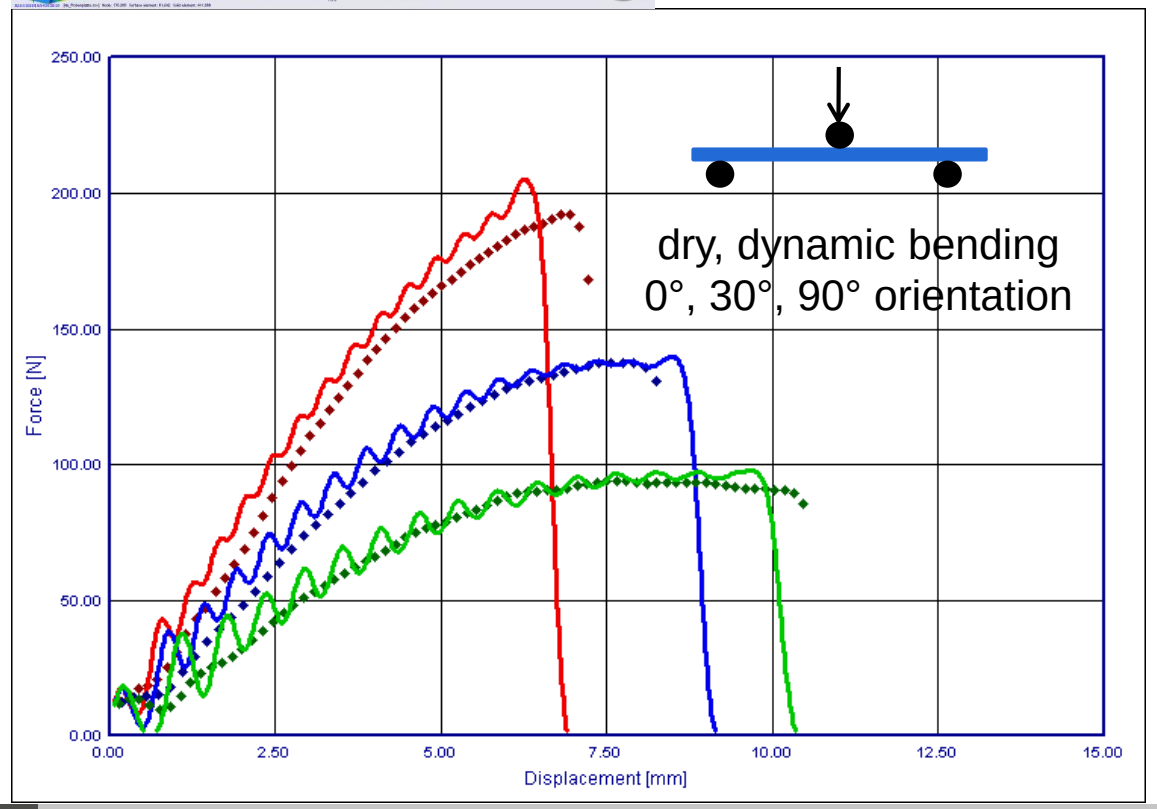
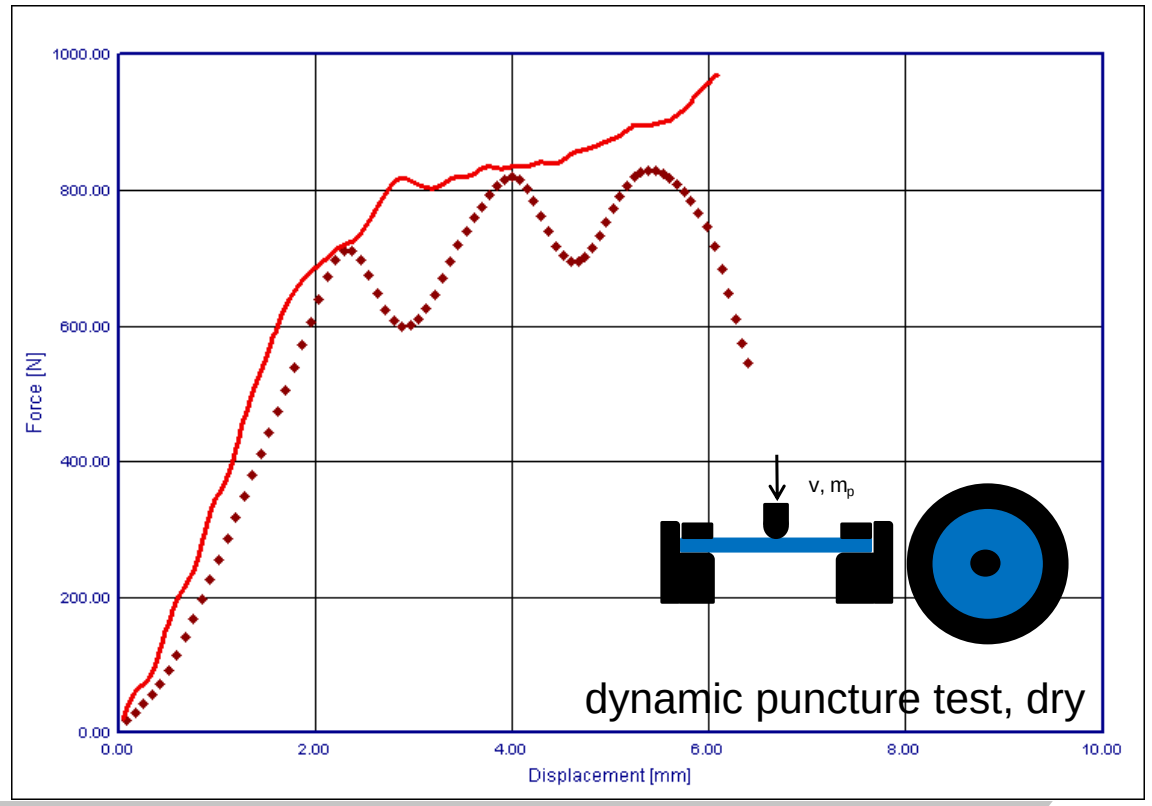


Scale of hardening curve ~20%





injection mold – process simulation & mapping

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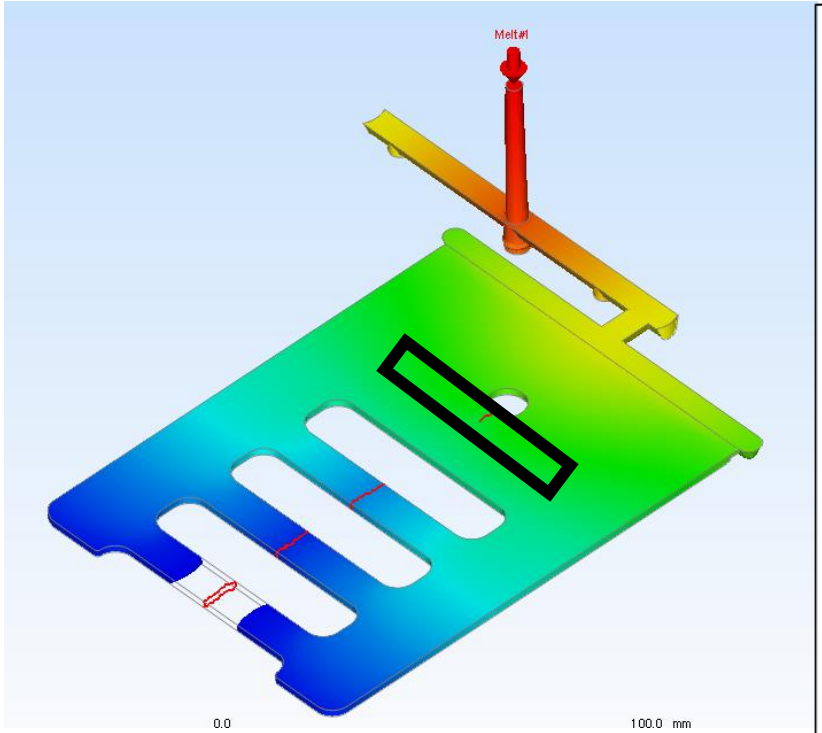
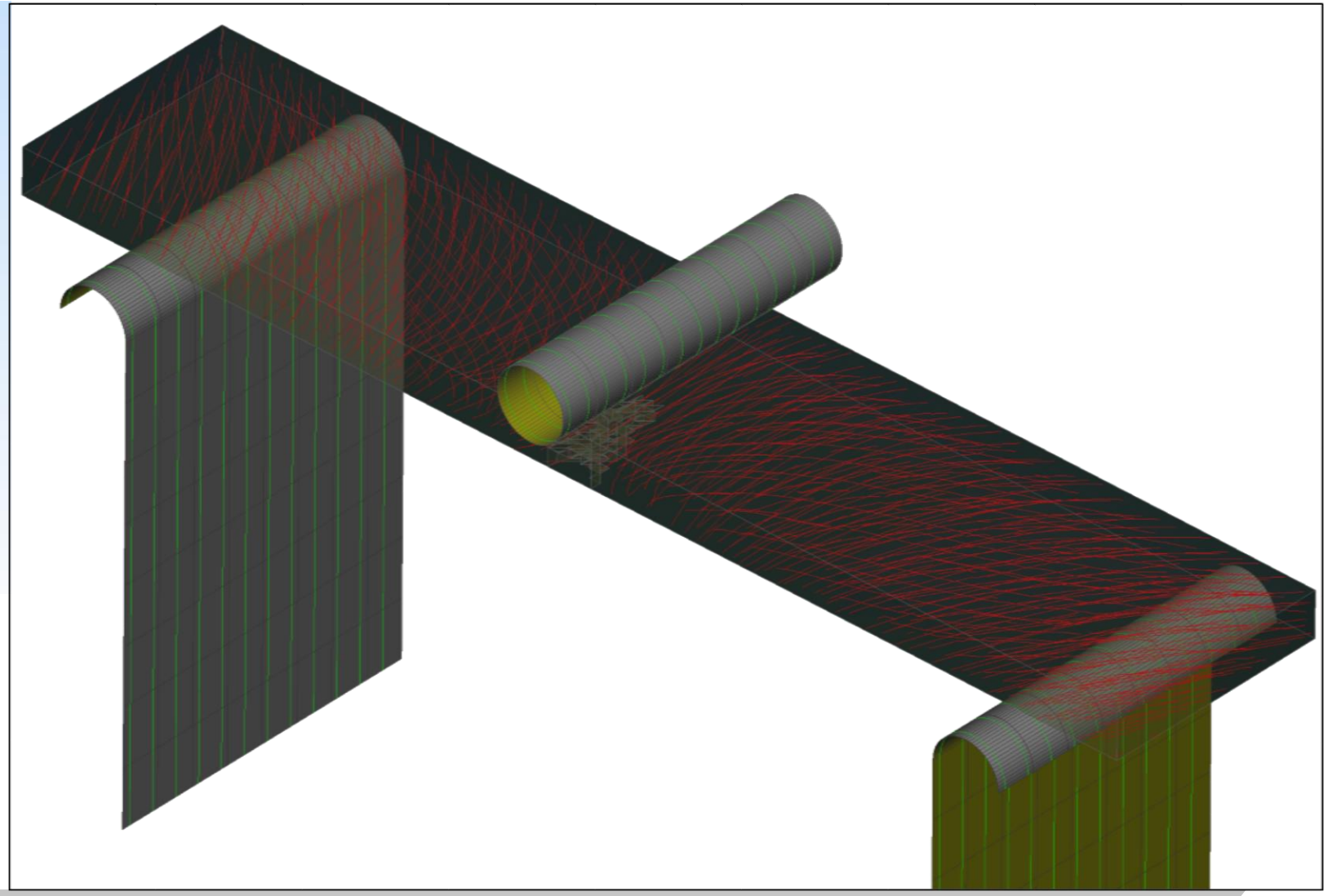
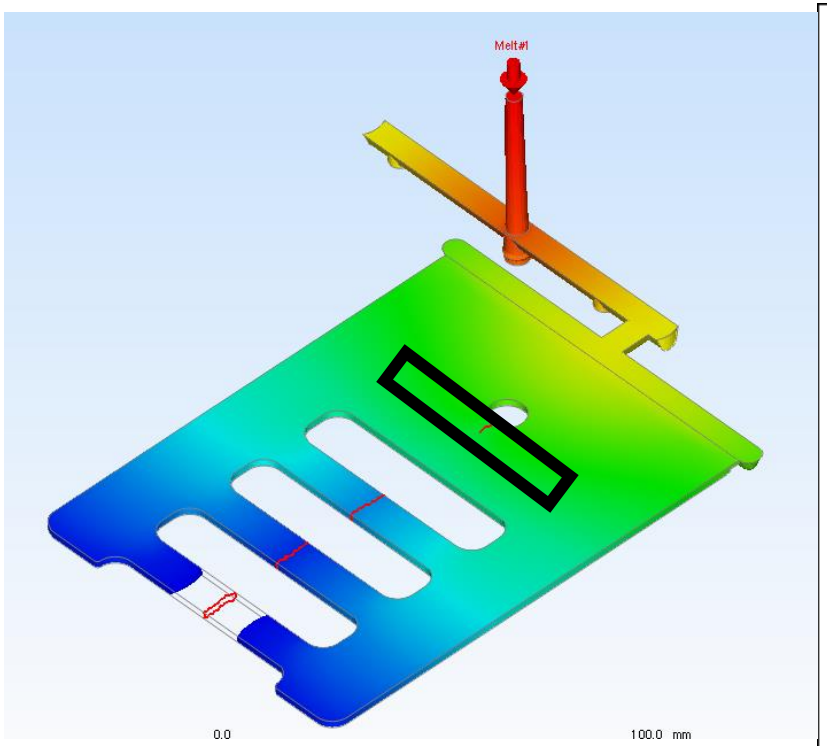


meltline



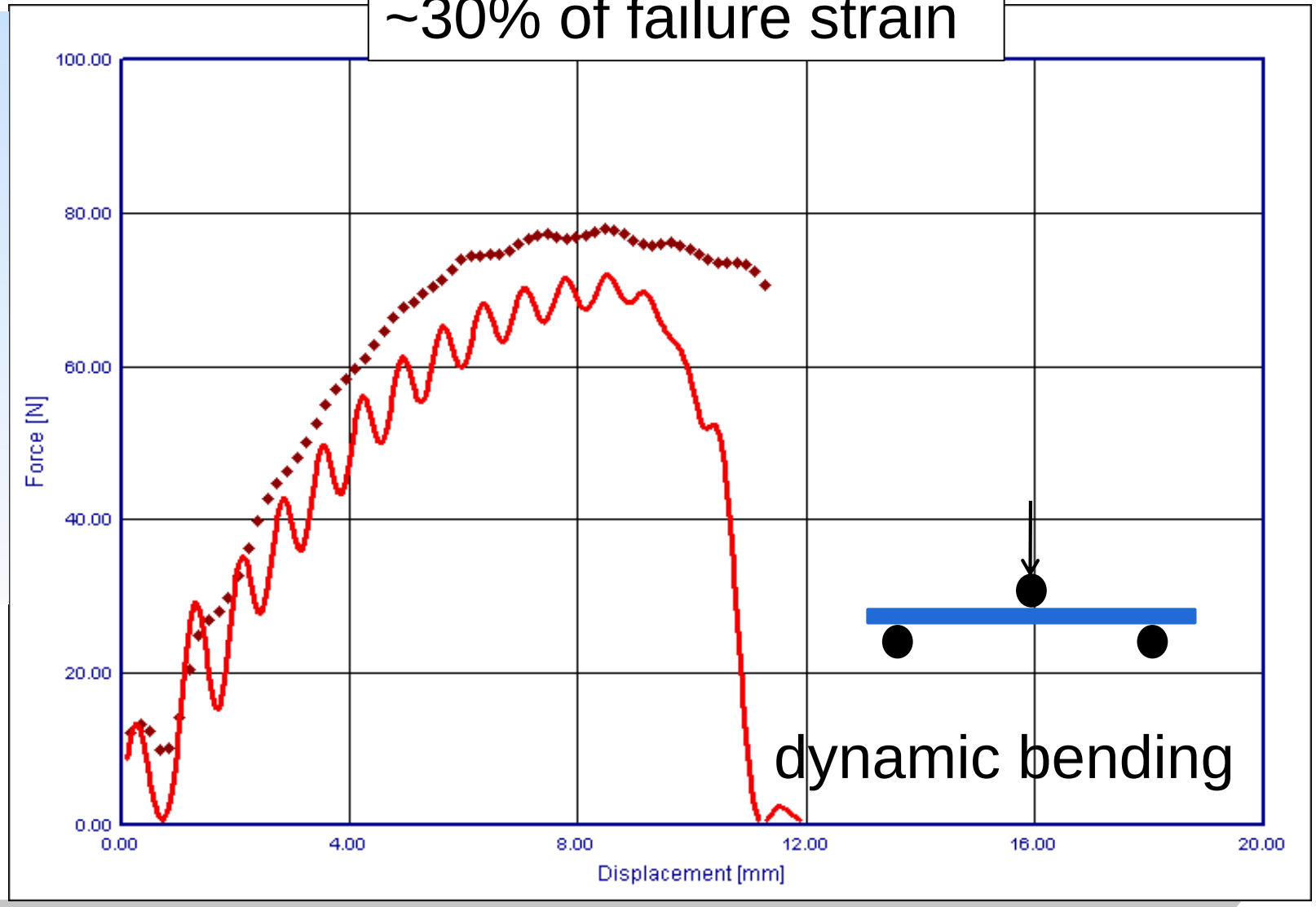
injection mold – process simulation & mapping

FIBERMAP



meltline

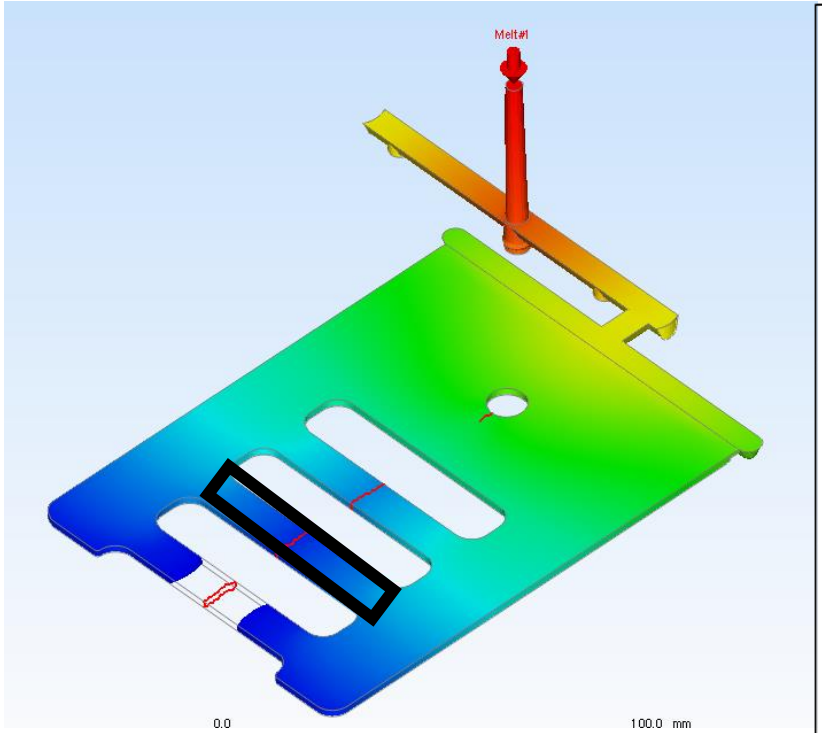
~30% of failure strain



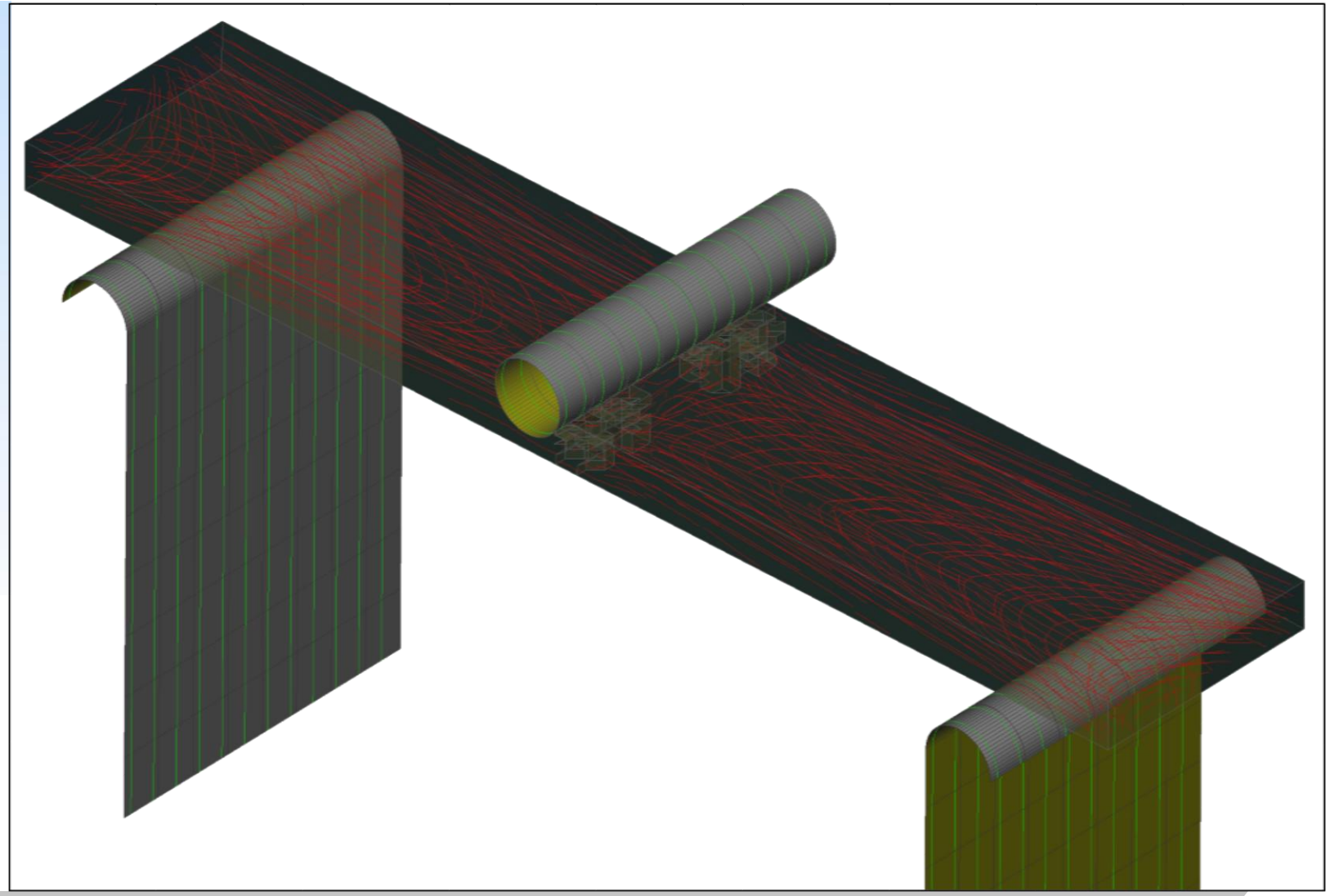
dynamic bending

injection mold – process simulation & mapping

FIBERMAP

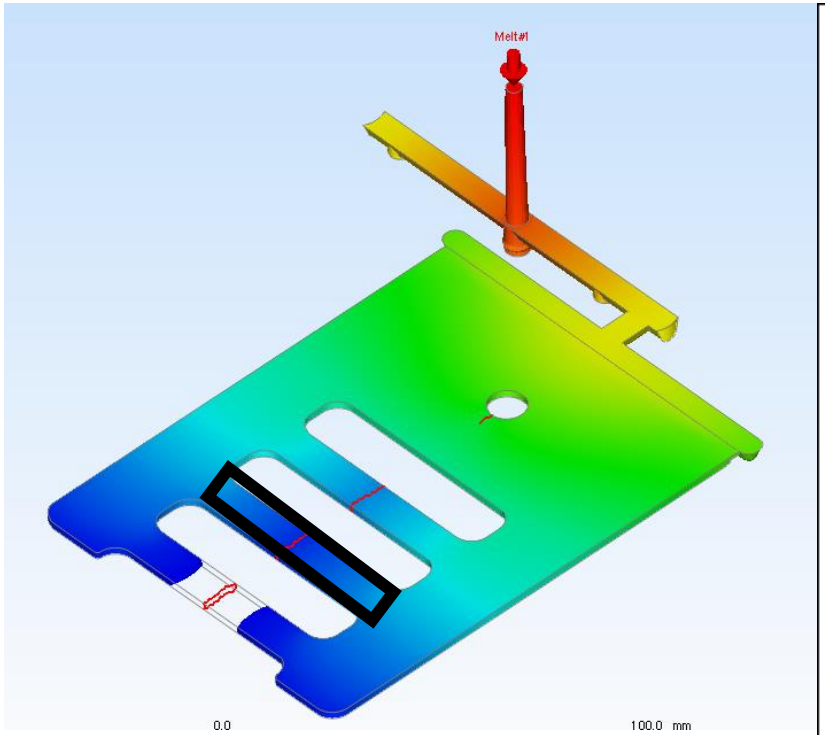


weldline



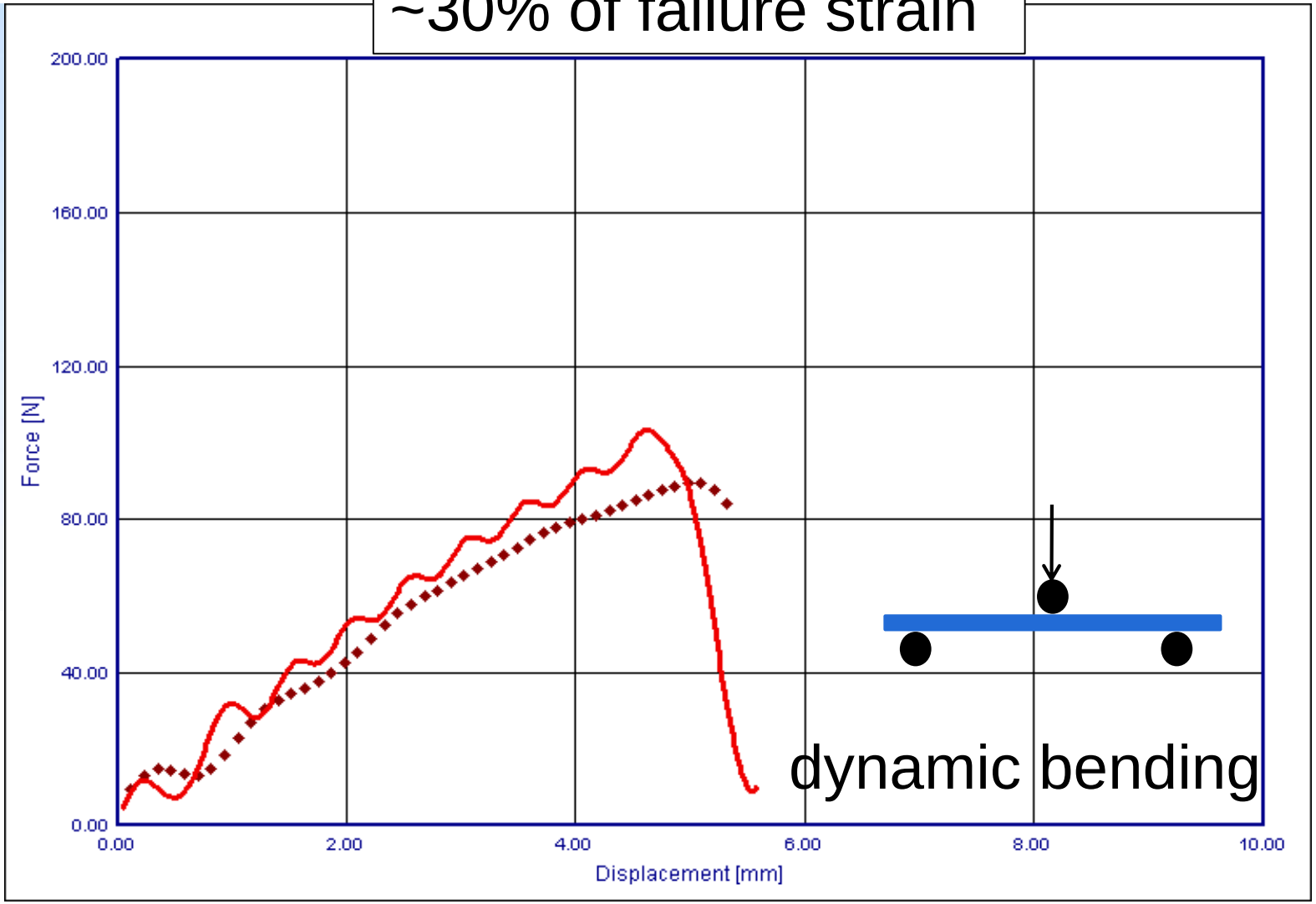
injection mold – process simulation & mapping

FIBERMAP



weldline

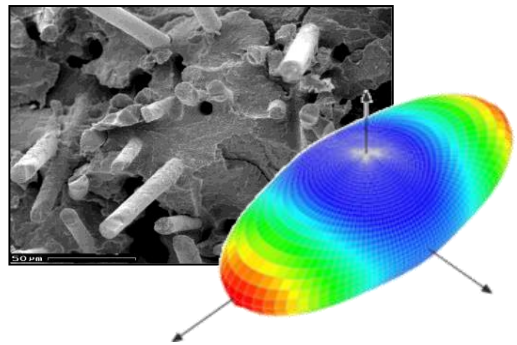
~30% of failure strain



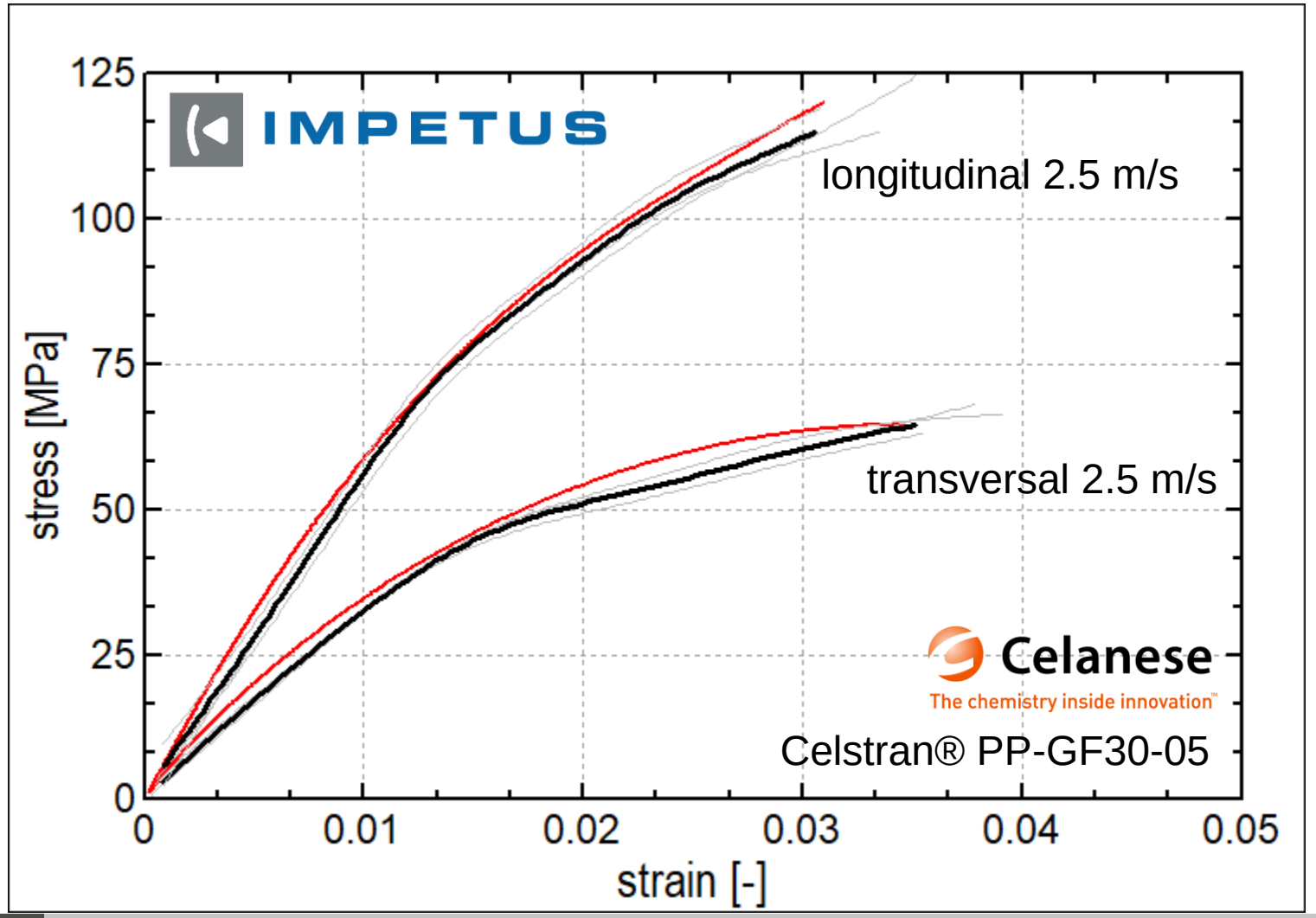
dynamic bending

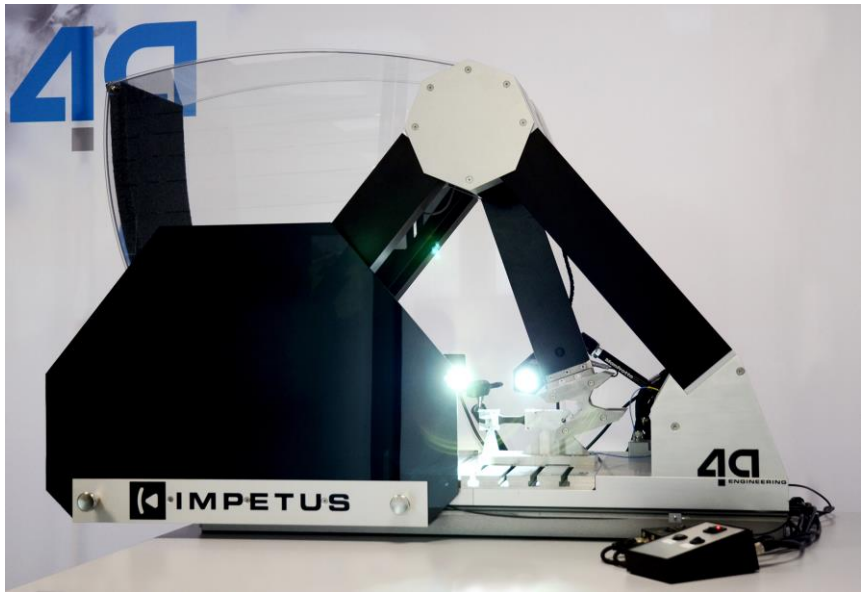
Summary & Outlook

- advantages ***MAT_215**
  - micro mechanical approach → **describe matrix dependent on moisture**
  - simulation process chain considering local anisotropy
    process → structural
- How to get ***MAT_215**
  - **measured behavior** can be described well
  - calibration by using **bending** and **puncture tests** good approach
  - using **µCT** results is a good starting point
  - **mapping** of injection molding simulation big influence
- Outlook
  - further investigation on component with “new” material cards (mapping)
  - further research on weldlines and general failure modelling



Outlook – investigations on further load cases





comparison
IMPETUS™ impact tensile versus
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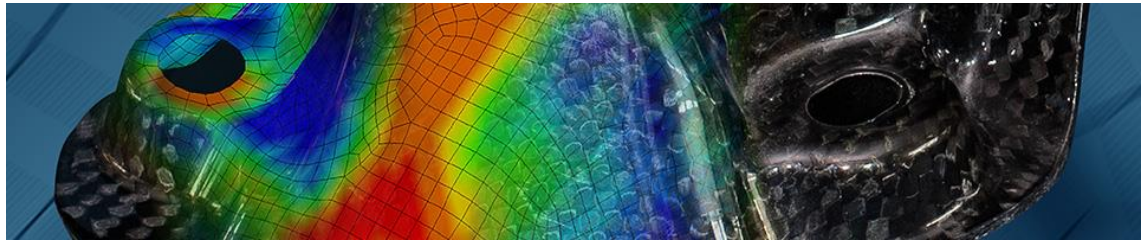

Thanks

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