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Simulation of Adhesives

Dynamore USER Forum in Bamberg 2014

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Leica Geosystems HEXAGON DRESDEN concept Exzellenz aus Wissenschaft und Kultur

Agenda

1. Problem description
2. Mechanical behaviour of adhesives
3. Tension-compression test results in p-q diagram at 20° C
4. Tension test over temperature
5. Modeling of adhesives in LS-DYNA
6. MAT124 and MAT252
7. Forecast

1. Problem description

- **Gluing joints** are **often** used as **Joining technic** in **optoelektronics**.
- **Virtuel prototyping** process with FEA for future requested.

Important are the following points:

1. **Influence** of the **gluing process**.

2. **Influence** of **thermal** and **mechanical loads**.

➔ System behaviour in respect to the loads.
➔ Reversibe and irreversile drift of the system should analysed.
➔ Optimization of the system (minimization of drift effects).
➔ Develope compensation models (reversible drift effects).

2. Mechanical behaviour of adhesives

The mechanical behaviour of adhesives are similar to plastics:

1. Dependency from the hydrostatic pressure

2. Compressible in the plastic area.

3. Temperature and rate dependency.

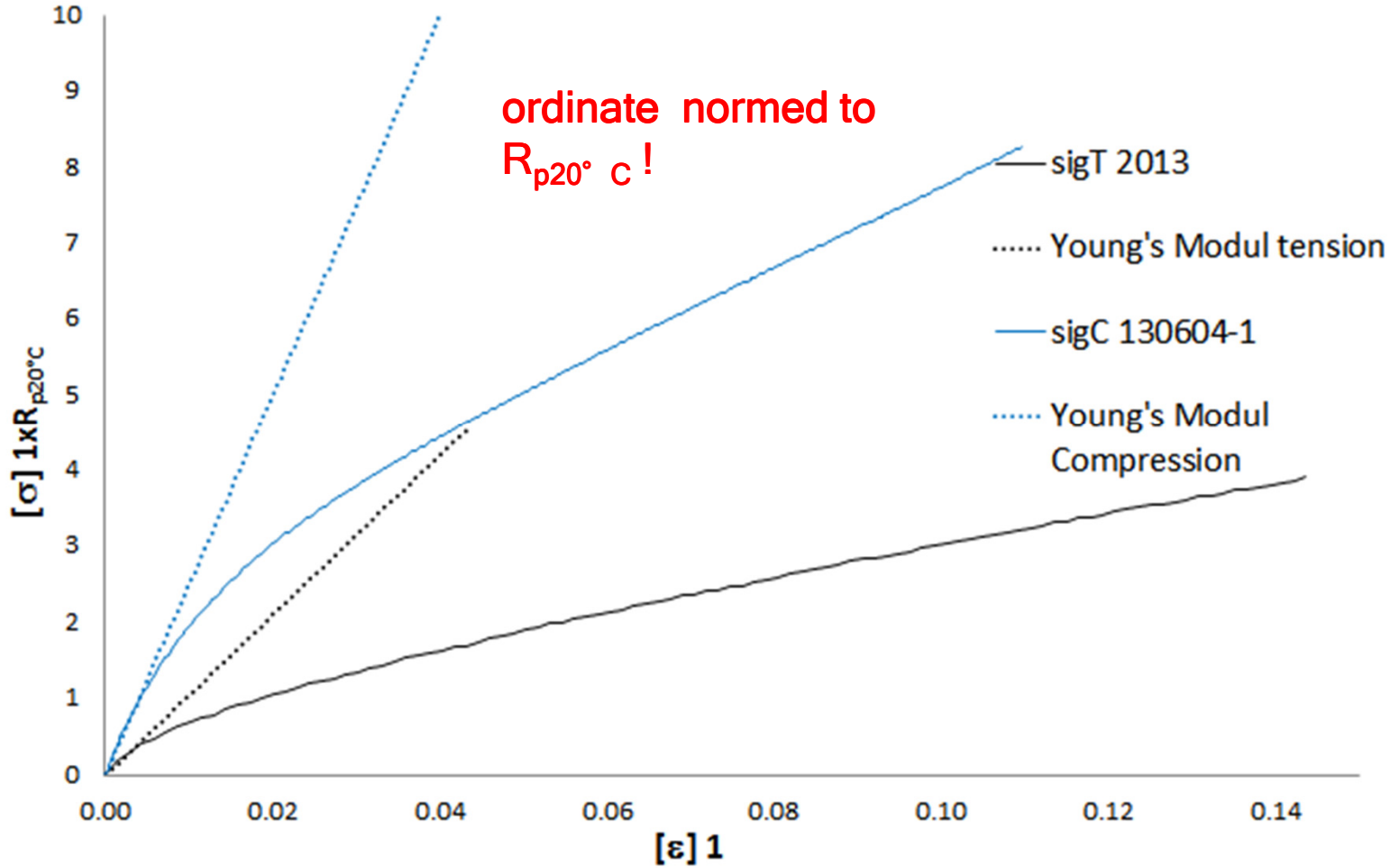
➔ Small gluing gaps induce a triaxial stress (obstruction of the lateral contraction).

➔ Influence of the Poission ratio!

➔ See publications from Prof. Schlimmer, Prof. Matzenmiller, etc.

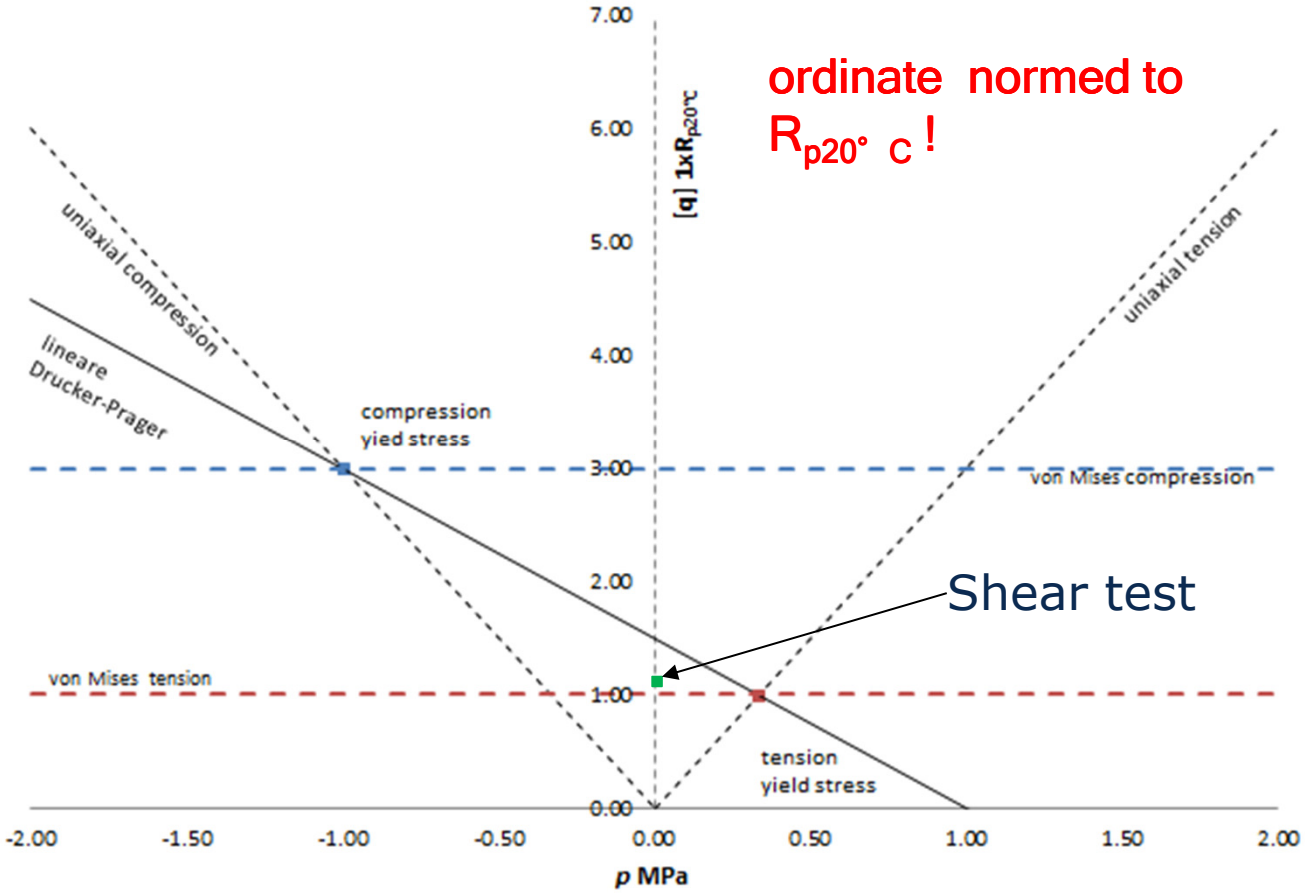
➔ **The VON MISES plasticity couldn‘t used for the modeling of the material behaviour of adhesive joints (plastic incompressible and no tension-compression asymmetrie)!**

3.1 Tension-, Compression test



➔ The comparision of tension- and compression-test show the asymmetric material behaviour of the epoxy adhesive.

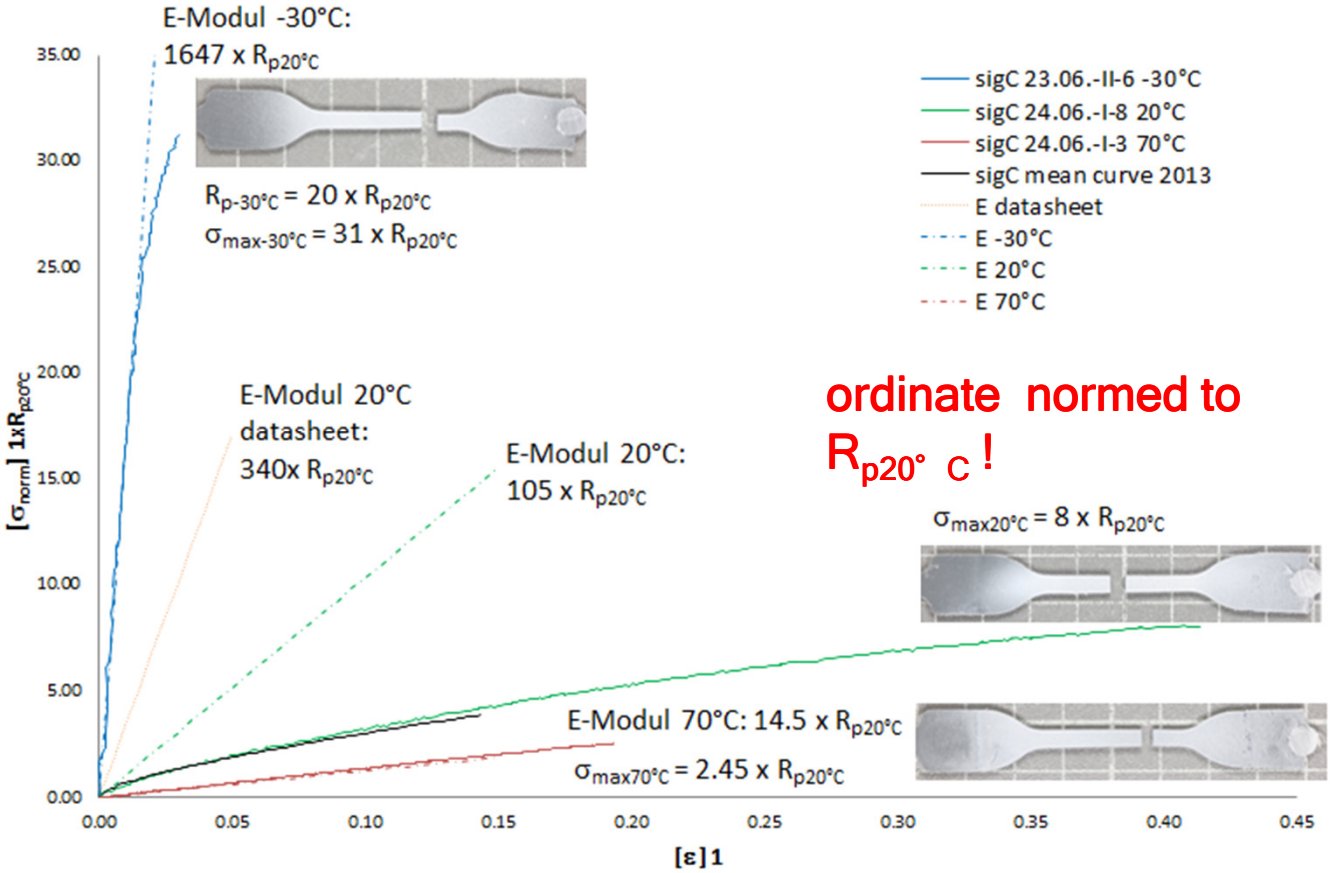
3.2 Tension-compression test results p-q diagram at 20° C



➔ The linear Drucker-Prager model is a better model for this adhesive.

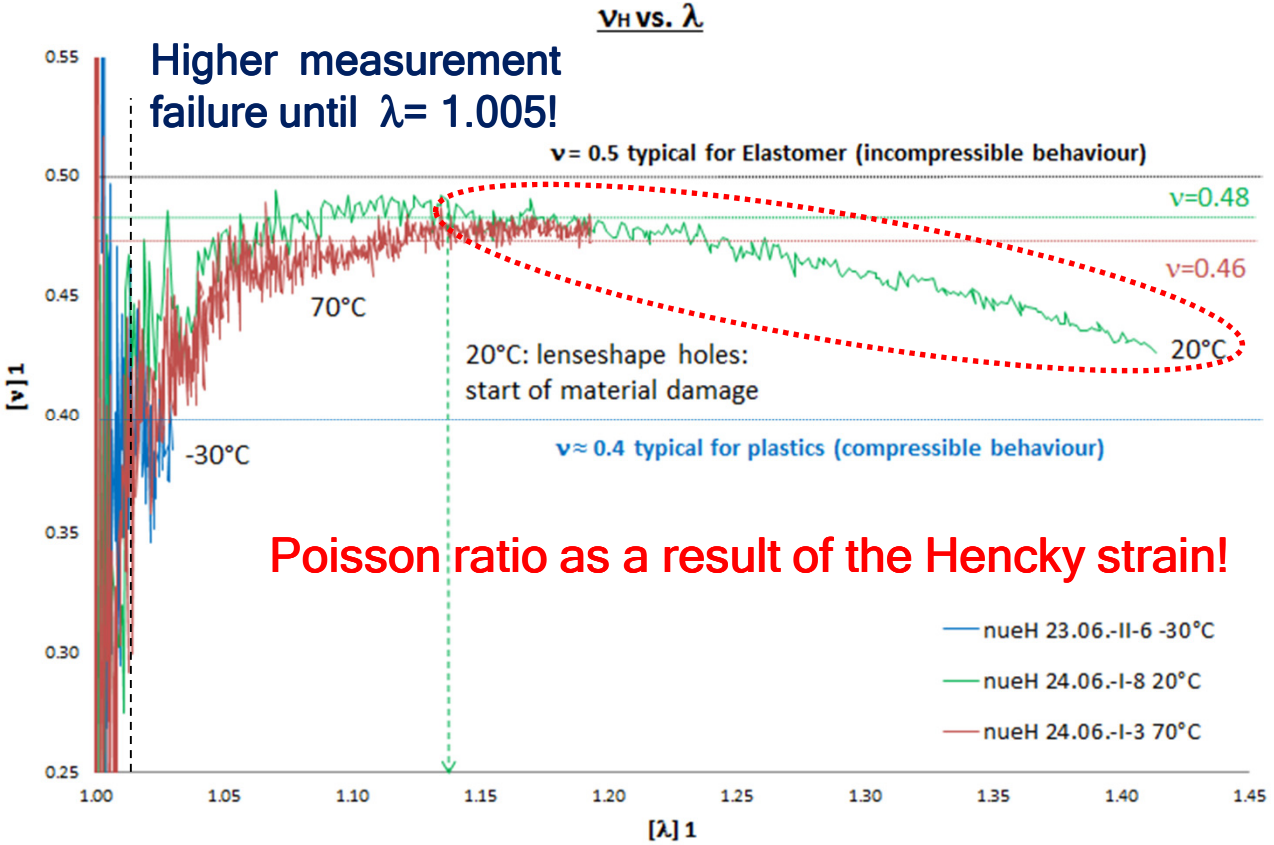
➔ The shear test results must be qualified with new results.

3.3 Tension test over temperature



- ➔ Static tension-, compression-, tension-shear-, torsion-shear- and 3-point bending test was done on the IWS Frauenhofer Institute in Dresden
- ➔ Simulation with only a viscoplastic materialmodel isn`t possible!
- ➔ Dynamic 3-point bending test´s (4a) over temperature have been done.

4. Temperature dependency of the poission ratio



Lense-shaped holes - Crazing:

- **material damage at this strain level!**
- **Could be used to model a Contiuum damage model (CDM) acc. LeMaitre, Kachanov, etc.).**
- **Could be used to define the max. strain for the material!**

- At 20° C the poission ration decrease from λ = 1.13 increase of compressibility mean a decrease of the poission ratio (Crazing!).
- Influence of the strain definition to the Poission ratio see: O. STARKOVA; A. ANISKEVICH: Polymere Testing 29 (2010) 310-318, University of Latvia Riga

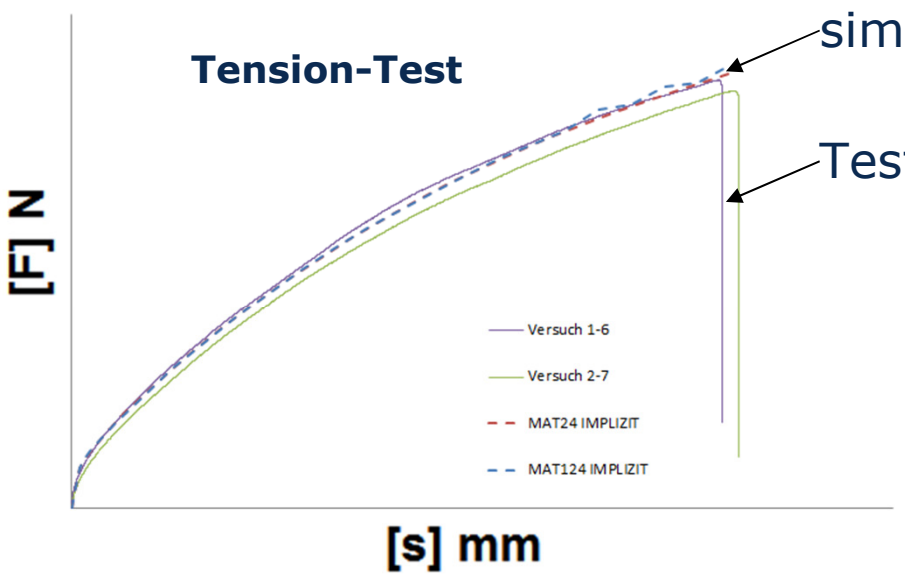
numerical modeling of adhesive joints in LS-DYNA

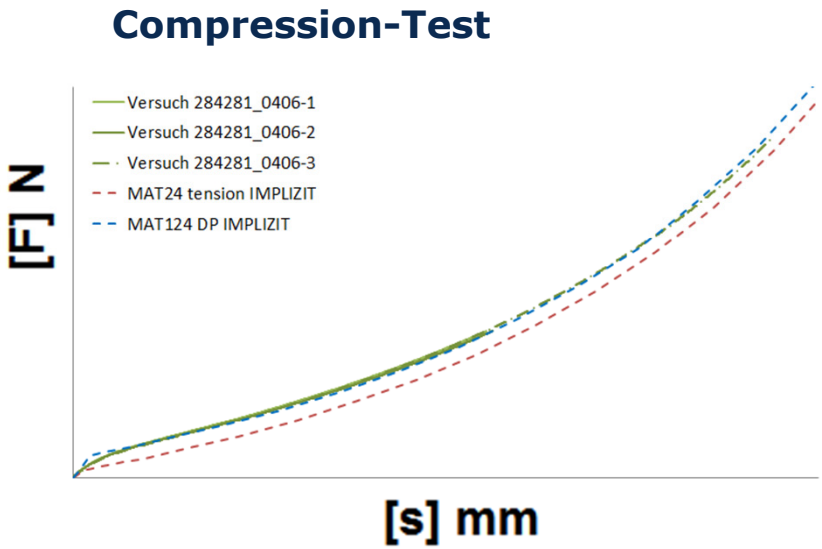
5. Modeling of adhesives in LS-DYNA

- Chemical shrinkage with *LOAD_VOLUME_LOSS.
- Thermal shrinkage with *MAT_ADD_THERMAL_EXPANSION.
- Material dependency from I_1-J_2 (MAT124/ MAT187/ MAT252 no temperature dependency).
- Different Youngmodul in tension and compression (MAT124).
- Material dependency from ϑ (MAT106 only with J_2 -plasticity)
- Also available for implizite simulations (MAT124/MAT106).
- Cohesive Zone Elements for big assemblys.
- Influence of poission ratio (over temperature none Materialmodel).

➔ Now there is no material modell available which allow the simulation of the mechanical **and** the thermal behaviour of elastoplastic adhesives.

6.1 MAT124 Tension-Compression

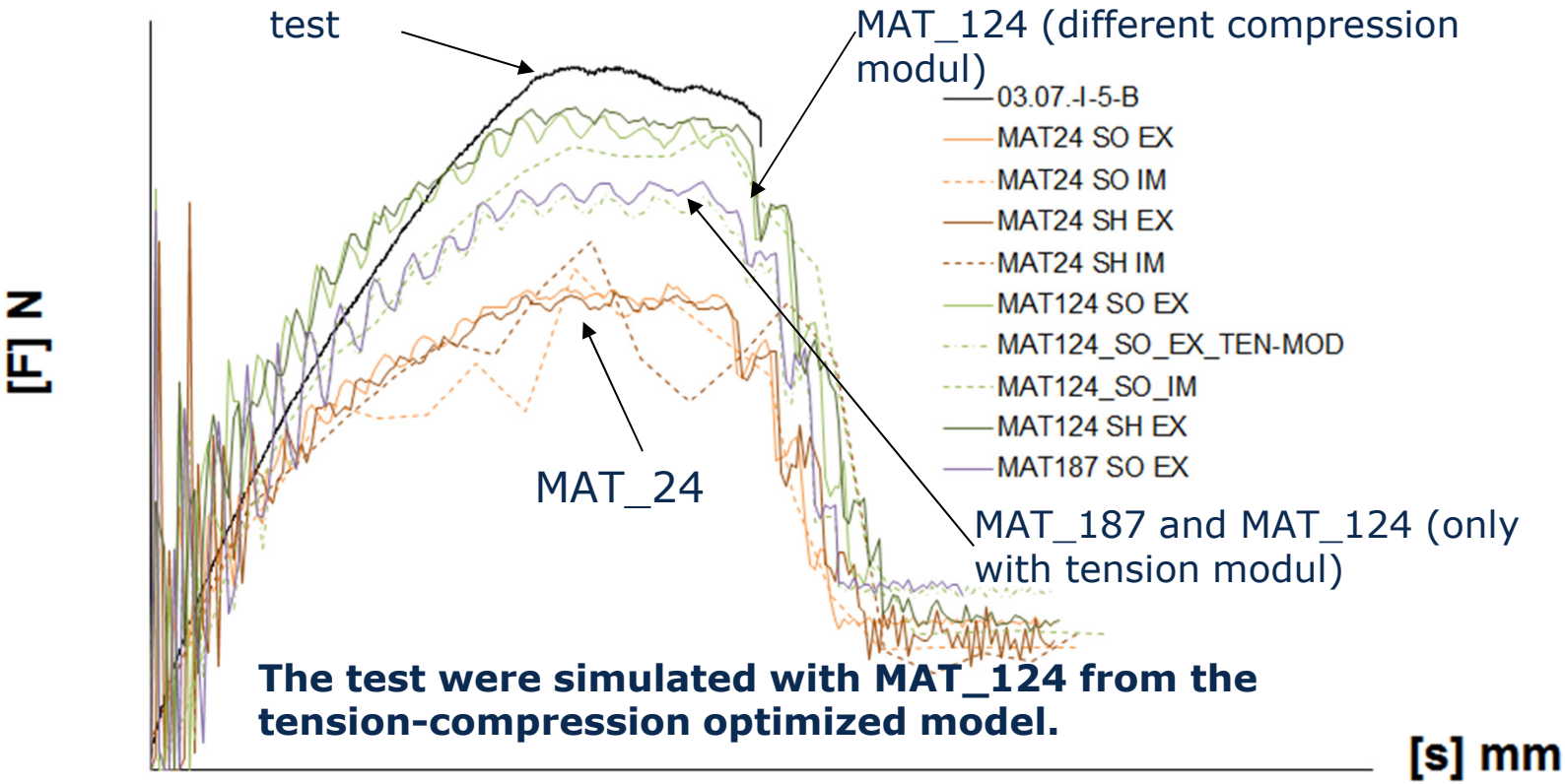




➔ **MAT124 allow the simulation of the tension-compression asymmetrie.**

➔ **The simulation model show a good accuracy to the test.**

6.2 MAT_124 three-point bending test



The test were simulated with MAT_124 from the tension-compression optimized model.

- ➔ **MAT_24 (von Mises Plasticity) show a big difference to the test.**
- ➔ **MAT_124 show a very good simulation result compared with the test.**
- ➔ **MAT_187 looks also very good – but it`s not so good as MAT_124.**
- ➔ **MAT_124 with only a tension modul show the same performance as Mat_187.**

6.3 MAT252 (MAT_THOUGHENED_ADHESIVE_POLYMERE

In tension area CAP-Model and in compression lineare DRUCKER-PRAGER:

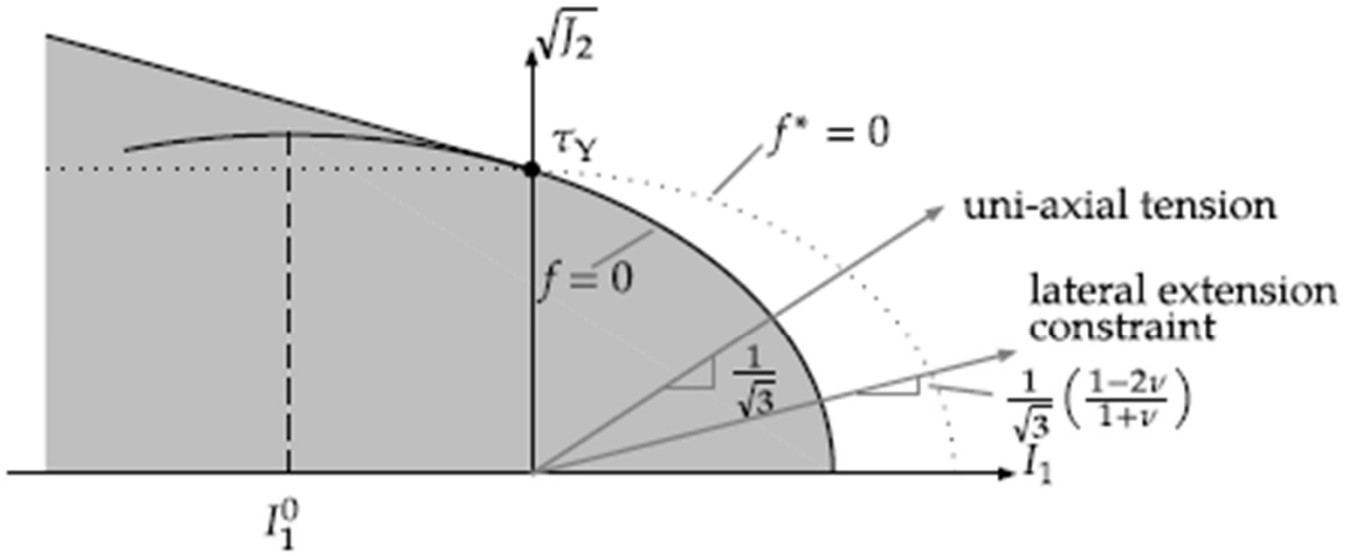


Figure 2-122. Yield function f and plastic flow potential f^*

$$f := \frac{J_2}{(1-D)^2} + \frac{1}{\sqrt{3}} a_1 \tau_0 \frac{I_1}{1-D} + \frac{a_2}{3}\left\langle \frac{I_1}{1-D} \right\rangle^2 - \tau_Y^2 = 0$$

Quelle:
LS-DYNA Keyword Manual Vol. II
Material Models 19 Mai 2014
Version R7.1 (Revision 5442)

With a flag in the compression area the von MISES Model will be activated!

7. Forcast

- Finish the **analysing** of the **test results – evaluation** of the **temperature dependet material model** and **definition** of the **material characterization process**.

- A **updated Materialmodell** must have the **possibility** for the definition of **different Young`s Modul** for tension and compression.

- **Upgrading of MAT 252** with the **tangent stiffness** and the **temperature dependency**.

OR

- **Implementation of the SCHLIMMER-MAHNKEN material modell** (was implemented in ANSYS and ABAQUS in the past) and upgrading with the **temperature dependency**.

»Wissen schafft Brücken.«