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Open-Minded

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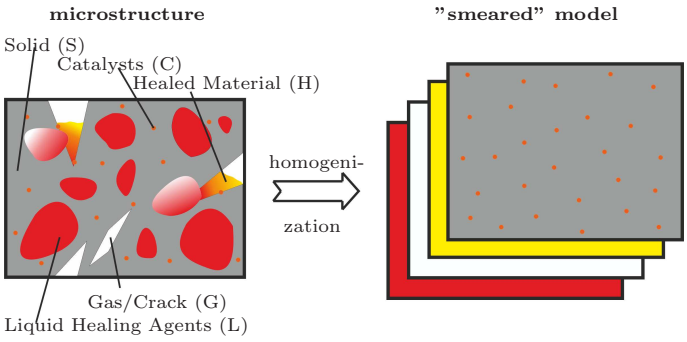
# A model for self-healing anisotropic composites

**SPP 1568**
**"Design and Generic Principles of Self-healing Materials"**
*The ultimate goal of the Priority Programme SPP 1568 is to provide a new generation of adaptive high-performance materials that can be used for various applications in technology and medicine.* `http://www.spp1568.uni-jena.de`

## Motivation

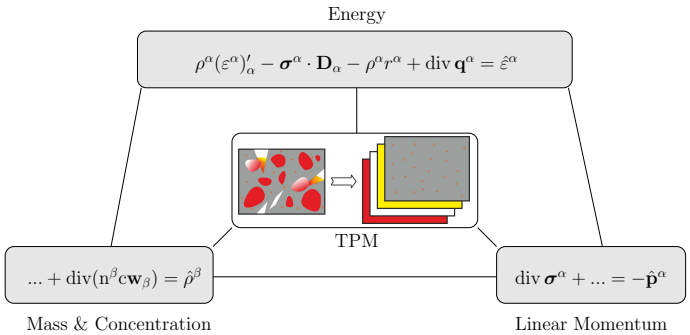
The idea of self healing materials is to deal with failures instead of preventing them. This enables an extension of life time with less material usage. Since the publication of [1], the number of researchers on this topic grows exponentially. Due to the fact that the manufacturing of such self healing materials and self healing systems are expensive, numerical simulations are very useful to estimate the material behavior.




## Theoretical Framework

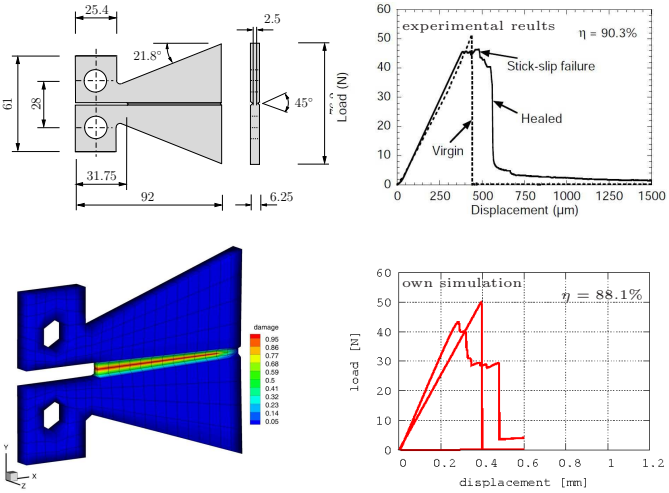
The Theory of Porous Media, cf. [2], corporates the Mixture Theory with the Concept of Volume Fractions. We consider a macroscopic homogenized multiphase model instead of the real microscopic system. All constituents, $\varphi^\alpha$ ($\alpha$ = S, H, L, G), are assumed to be statistically distributed over the whole control space and have separate motion functions $\chi_\alpha$, but they appear simultaneously in every material point $\mathbf{X}$ at the same time (superposition). This leads to the required saturation condition, which states that the sum of volume fractions over all constituents in a material point must be equal to one, i.e., $\sum^{\alpha} \mathrm{n}^\alpha = 1$.

## Field Equations

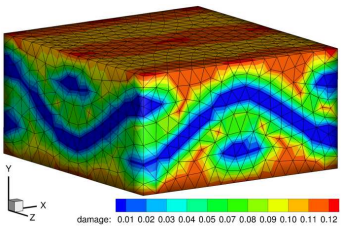



## Experiment versus Simulation

Damage and healing behavior of a tapered double cantilever beam (TDCB), cp. [3]:



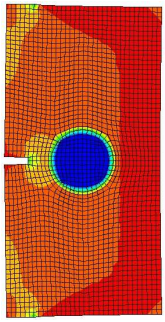

Woven fiber composite structure - distribution of damage:




## Work Plan for the Second Funding Period

Development of a micromechanical model for the polymer with encapsulated healing agents.

-investigation of the motion of liquid
-influence of local damage on the permeability
-study of damage behavior for different shells



Mesomechanical modeling of self-healing fiber reinforced composites.

-transfer of microscopic behavior to larger scale
-matrix: multiphase self-healing material
-analysis of homogenized macromechanical behavior

Numerical simulation of experiments, identification of material parameters, set up of constitutive laws and evolution equations.

Potential cooperation partners: S. van der Zwaag (TU Delft) and C. Papadakis & B. Rieger (TU München)

## References

[1] S.R. White *et al.* [2001], *Nature*, 409:794–797
[2] Ehlers, W. & Bluhm, J. [2002], *Porous Media*, Springer
[3] E.N. Brown *et al.* [2002], *Experimental Mechanics*, 42: 372–379

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