Foam mechanics unraveled
Opportunities for structure-property optimization


Introduction
The outstanding properties of polymer foams are a direct result of the subtle interplay of the polymer base material and the foam’s micro-structure [1]. In general two types of foams can be made, namely rubbery open celled and glassy closed celled foams (Fig. 1).

Glassy closed celled foams have a good energy absorbing capacity with low resilience, whereas the rubbery open celled foams have a high resilience but low energy absorbing capacities. When the best of two can be combined, new materials can be introduced for applications such as car bumpers.

Goal & Approach
To establish a direct link between the micro-structure and the intrinsic response, FE simulations are executed, employing microstructural details derived from X-ray CT images combined with a constitutive model for the base material (Fig. 2).

Applications
Mechanical response
The method allows for exploring the mechanical response in various loading geometries (even those not feasible in experiments). This enables the characterization of the volumetric response which extremely differs in tension, shear and compression (Fig. 3a). Also the influence of the intrinsic material response on the energy absorbing capacity of foam can be evaluated with this technique (Fig. 3b).

Prototyping
In combination with new developments in stereolithography rapid prototyping (high resolution, tough resins), this technique provides the direct means for structure-property optimization. An example is shown in Fig. 4 where an open-celled structure with glassy base material is shown (with common techniques impossible to realize).

Future work & applications
- mechanically characterize prototypes structures;
- extend to larger structures (more cells in structure);
- prototyping of optimized micro-structures [2].

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References: