Design of a conformable shape element that can be integrated into a consumer electronic device. Multiple shaping cycles have to be possible and the mechanism has to be self-contained. In addition to fulfilling the application requirements, it will also be necessary to find materials solutions compatible with cost effective mass production and daily use conditions. Especially mechanical robustness and operating temperatures have to be considered.

Materials

The foam samples were prepared in a one shot process using a commercial two component polyurethane resin system. Water was used as a chemical foaming agent and the cellular structure was stabilized with silicone oil leading to a homogenous open cell foam.

**Objective**

Shape Memory Polyurethane for a Tunable Grip

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**Approach**

Shape Memory Polymer (SMP) Foams are used as deformable material. The SMP is capable of retaining a “programmed” temporary shape and recovering its permanent shape upon actuation as illustrated in Fig. 1. The foam’s compressibility is defined by the porosity. Thermal activation is used as a trigger and Jule heat is directly generated inside the foam by a wire coil.

Dynamic Mechanical Analysis (DMA) was used to characterize the thermomechanical behavior of the prepared materials. The suitability of DMA for predicting materials behavior was also evaluated in comparison with the results of direct testing of the shape memory effect.

**Results**

Shape fixity at constant temperature

Figure 3 illustrates the clear correlation observed between the fixity of various SMP foams at 40°C after deformation above Tg and cooling (see Fig. 2) and the materials’ thermodynamical properties. These can be visualized with DMA tan delta temperature scans. It is seen that for good fixity to be obtained in this temperature range the onset temperature of the tan delta peak must be at least 50°C.

![Fig. 3: (a) Shape recovery at 40°C for four foams with different chemical compositions. (b) Corresponding results for tan delta from DMA temperature sweeps at 1 Hz.](image)

Shape recovery during temperature ramp

Dynamic recovery behavior was characterized by imposing a constant temperature ramp (1°C/min) while monitoring sample expansion from the compressed state. Figure 4 illustrates that the onset of significant recovery under these conditions occurs at temperatures similar to the onset temperature of the tan delta peak in the DMA scans.

![Fig. 4: (a) Shape recovery as a function of temperature during a temperature ramp (1°C/min) for foams with three different chemical composition. (b) Corresponding results for tan delta from DMA temperature sweeps at 1 Hz.](image)

**Conclusion**

The feasibility of preparing a shape memory element with practical requirements for a heat-actuated tunable grip has been established. Design criteria have been met for the element shape, element mass, the thermodynamical material properties, the material density as well as the integrated heating system. Furthermore it was shown that Dynamic Mechanical Analysis temperature scans are a reliable tool for evaluating the relevant thermomechanical response of the different materials considered. This allowed fabrication of a simple functional demonstrator for the application under consideration.

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