Long cycle-life shape memory polyimide with energy-storage capacity at high temperature

Shape memory materials such as shape memory polymers (SMP) and shape memory alloys (SMA) have been used in many fields. SMP possesses advantages such as easy process, large recoverable strains and light weight over SMA, but long cycle-life is rarely observed in SMPs.

Here long cycle-life SMP is reported for the first time, and it is prepared with polyimide possessing highly twisted molecular chains. The shape memory polyimide maintained both high shape fixity (R_f) and shape recovery (R_r) of about 100 % during the more than 1000 bending deformation cycles tested, as manifested in Figure 1A.

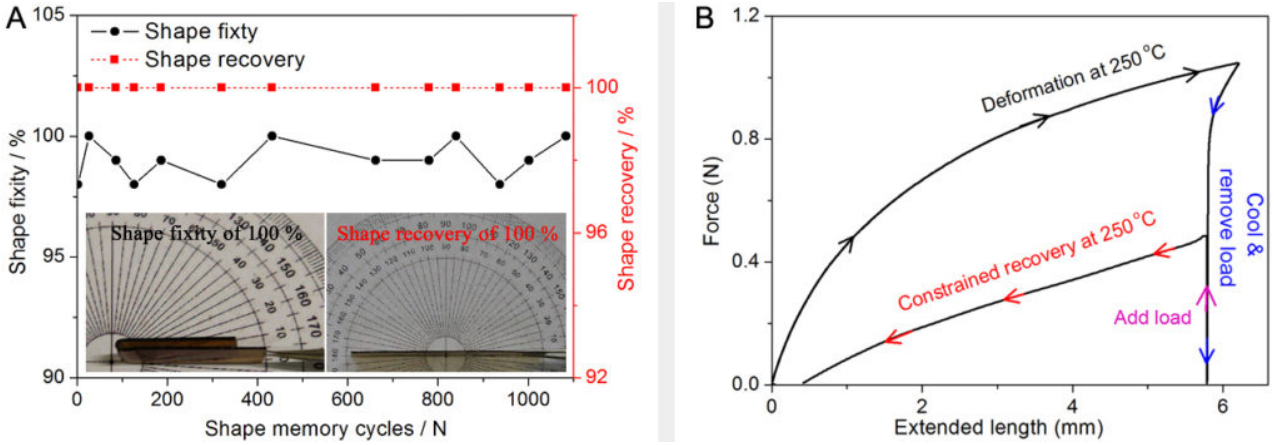

Fig. 1. A. Overview of shape memory performances of the polyimide during the bending cycles, and the inlets are images of complete shape fixity and shape recovery states. B. Stretching and stored energy of the polyimide in a shape memory cycle at 250 °C.

The mechanical work that shape memory material can perform during shape recovery process is of great importance for its practical applications, and here energy-storage capacity of SMP at high temperature is reported for the first time. The polyimide can produce energy of 0.218 J g^{-1} with the efficiency of 31.3 % during shape recovery process at 250 °C, as shown in Figure 1B.

This polyimide possesses wide operating temperature range of 230 °C to 300 °C, during which it can achieve shape recovery of 100 % within 20 seconds. The combination of long cycle-life, energy-storage capacity and wide operating temperature range makes the polyimide a suitable candidate for high temperature applications requiring numerous shape memory cycles such as reversible actuators and deployable hinges.

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