DLP printing of shape memory polymers

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Shape memory polymers (SMPs) are intriguing stimuli-responsive materials presenting the ability to fix a temporary shape and return to their permanent shape once exposed to an external trigger such as water, light, pH variation, or heat, which is the most widely investigated triggering mechanism. Recently, the use of SMPs in 3D printing (3DP) led to an exciting extension of this technology, defined as 4D printing, able to overcome the static nature of traditional 3D printed structures. Among the 3DP technologies for polymeric materials, those based on light-induced polymerization of liquid resins and, among them, digital light processing (DLP), are attracting a high interest due to their microscale resolution and versatility in the design of the material.

In this frame, we'll present the development of a simple photopolymerizable system based on monomers containing reversible binding groups for the fabrication of DLP printable SMPs. In detail, 2-hydroxyethyl methacrylate (HEMA) and poly(ethylene glycol) methyl ether methacrylate (PEGMEMA), together with a crosslinker were used as photopolymerizable ingredients. The 3D printable polymers showed an excellent thermally triggered shape memory response. Moreover, the possibility to easily design the glass transition temperature of the SMPs by varying the concentration of the two photopolymerizable ingredients allowed to fine-tune the formulations such that materials can be printed showing shape memory behavior at different temperatures. [1]

To make a step further, carbon nanotubes (CNT) were then embedded in the SMP matrix enabling the electrical conductivity and thus the possibility to remotely heat the nanocomposite using the Joule effect. The feasibility to drive a shape memory cycle via Joule heating was then proved, confirming the significant electrically-triggered responsiveness of such CNT/SMP. Finally, a modular and selective electro-activated shape recovery was activated, which may ultimately envisage the 4D-Printing of remotely and selectively controllable smart devices. [2]

[1] A.Cosola, M. Sangermano, D. Terenziani, R. Conti, M.Messori, H. Grützmacher, C.F. Pirri, A. Chiappone *Applied Materials Today* 23 (2021) 101060

[2] A. Cortés, A. Cosola, M. Sangermano, M. Campo, S. González Prolongo, C. F. Pirri, A. Jiménez-Suárez, A. Chiappone. *Advanced Functional Materials* (2021) 2106774