The design of 3D printed plastic actuators based on the the shape memory effect of polymers

Andrea Vigliotti[1], Angela Ferrigno[2]
[1] *Innovative Materials Laboratory, Italian Aerospace Research Centre, Capua 81043, Italy*
E-mail:a.vigliotti@cira.it
[2] *Innovative Materials Laboratory, Italian Aerospace Research Centre, Capua 81043, Italy*
E-mail:a.ferrigno@cira.it

Keywords: lattice mechanics, shape memory polymers, active materials

Shape memory polymeric lattice materials are an interesting example of a multiphysics/multiscale system. The macroscopic performance of the lattice is the result of both of the state-transformation of the polymer between its rubbery state and its glassy state, and the micromechanics of the lattice. Shape recovery in polymers takes place as the number of cross-links among the polymer chains drops upon heating above the glass transition temperature of the material and it is free to return in its initial shape. Such shape recovery can also take place in the presence of elastic constraints. In these cases the material is capable to produce a mechanical work against external forces, and can be used as the base material for an actuator. The proper selection and design of the topology of lattice, can help in maximising the performance of the actuator in view of a specific application. For instance, in some applications it might be preferable to maximise the actuator stroke, while in other high forces might be required, or faster actuation time. In this study we couple a thermodynamic based constitutive model for the solid material of the lattice, that includes the effect of external forces on the shape recovery kinetics, with a micromechanical model of the lattice that takes into account the geometric non linearities arising in the recovery of large deformation. The model has been used to design cylindrical actuators with a lattice microstructure. The topology of the lattice has been selected in order to guarantee zero macroscopic Poisson's ratio even in the presence of large displacements, in order to avoid the insurgence of states of self stress during actuation and maximise actuators efficiency. The final designs have been printed with a STL polymeric 3D printed and experimentally tested under different recovery conditions.

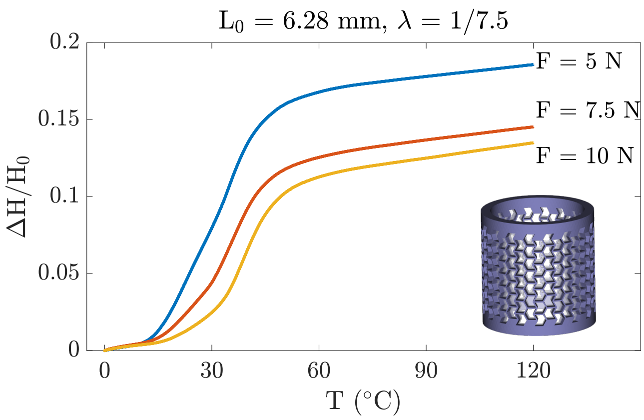

Figure 1: Experimental temperature-displacement diagrams of a 3D printed plastic actuator based on the shape memory effect of polymers for constrained recovery against different external forces