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Shape Memory as a Process: Optimizing Polymer Design for Shape Recovery RICHARD VAIA, HILMAR KOERNER, KYUNGMIN LEE, ROBERT STRONG, MATTEW SMITH, HUABIN WANG, TIM WHITE, LOON-SENG TAN, Air Force Research Laboratory — Shape memory is a process that enables the reversible storage and recovery of mechanical energy through a change in shape. Polymers provide a unique alternative to kinematic designs and other materials (e.g. metallic alloys) for applications requiring large deformation and novel control options. The effect control of storage and relaxation of strain energy associated with chain deformation depends on the nonlinear visco-elasitc behavior and glassy dynamics of the polymer network. Considering the molecular understanding of rubbery elasticity, chain entanglements in concentrated polymer liquids, affine deformation of networks, and glass fragility, heuristic guidelines can be formulated to optimize the molecular design of a polymer for shape memory. These are applied to the development of a polymer system for shape memory processes at high-temperature (200^{o}C). The low-crosslink density polyimide exhibits very rapid shape recovery, excellent fixity, high creep resistance, and good cyclability. Furthermore, the molecular design affords a very narrow temperature range for programming and triggering shape change that can also be accessed by photo-isomerization of the cross-link nodes.

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