

# **Autonomic Self-Healing and Materials Regeneration**

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We have previously demonstrated efficient and repeated self-healing of microcrack damage in polymers using capsule and vascular modalities for delivery of repair agents. More recently these concepts have been extended to the repair of damage in fiber reinforced composites and the restoration of electrical conductivity in circuits. While microcrack healing extends the lifetimes of devices that are limited by fatigue damage, the autonomic repair of damage from isolated, energetically intense events such as impact or blast loadings is an unsolved problem. The defective regions from highly intense events are of macroscopic dimensions and characterized by significant mass losses and high crack densities. Extension of previously developed self-healing concepts to the repair of irregular and unpredictable puncture damage characteristic of blast and impact loadings motivates the need for synthetic materials regeneration. Synthetic materials regeneration aims to restore lost functionality by autonomic processes that mimic biological growth of tissue and appendages. A robust autonomic regeneration process must first transfer sufficient healing fluid to span the voids in the zone needing regeneration. Delivery of large quantities of healing fluids is achievable using vascular networks fabricated in composite matrices; however, the gap-filling process must also contend with environmental forces, minimally gravity, as well as other factors such as wind, variable temperature, moisture and oxygen. After filling the voids, the fluid must then transform into a structural solid that has high strength and stiffness. To fill voids caused by puncture damage, we are developing novel gap-filling fluids that transform from a liquid, to a gel-like scaffold, to mechanically strong solid polymers. Surface tension between the liquid healing agent and the damaged solid, as well as the fluid's time dependent viscosity are physicochemical parameters critical to the success of the process. Characterization data on filling prototypical voids in vascularized polymeric specimens will be presented, including the scaffold-forming chemistry, its transformation to a structural solid and the evolving mechanical properties.