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# Stitched shape memory alloy wires enhance damage recovery in self-healing fiber-reinforced polymer composites

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**Abstract.** A major issue in composite technology is matrix micro-cracking due to low-velocity impact damage, which may severely limit service lifetimes of composite parts. In a novel approach, remarkable levels of healing of impact damage are obtained using shape memory alloy (SMA) wires to close longitudinal cracks in woven glass fibre-reinforced polymer plates with an epoxy-polycaprolactone (EP-PCL) matrix that shows dual-phase continuity. Thermal actuation of SMA wires stitched through the thickness of the stacked glass fibre plies introduces compressive loads to the cracks thanks to anchoring of the SMA loops at the fabric surfaces and debonding of the intervening threads, which prevents local deformation of the SMA, so that crack closure by about 200 μm is achievable. Concomitant expansion of the vascular network formed by the molten PCL fills the compressed cracks, resulting in highly effective healing on cooling, as demonstrated by C-scan images. Specimens stitched with SMA wires hence show almost complete healing, i.e. damage area recovery of 85 %, after low-velocity impact at up to 17 Joules followed by heat treatment at 150 °C. This represents a 55 % improvement over previous results for unstitched EP-PCL composites, and hence significantly greater degrees of healing than so far reported for this range of impact energies and this type of system.

**Keywords:** Self-healing, Functional composites, Fracture toughness, Impact behaviour, Interfacial strength