

FROM REACTIVE MULTILAYER NANOFOILS TO SELF-HEALING METALLIC SYSTEMS

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An open challenge in materials science is to expand the pervasive concept of self-healing demonstrated for polymeric composites to metallic materials. The attainment of self-healing behavior in metallic systems is intrinsically more challenging than for polymeric materials because of different characteristic energies involved in the healing process. In the present work, we propose a novel approach towards self-healing in metallic systems based on the use of Reactive Multilayers NanoFoil (RMNFs) as intrinsic heat sources within thin films. RMNFs are binary-layered structures that exhibit a negative enthalpy of mixing. The functional metallic thin film is deposited on top of a “healing layer” and the Heat Source. Ni/Al, one of the most known and studied reactive systems, was selected as the heat source of choice as it shows a strongly exothermic, fast reaction to form NiAl body centered cubic phase. Self-propagating reactions induced in the reactive section of the multilayer stack have been exploited to induce strong heating in top metallic layers. Upon heat release, the “healing layer” undergoes localized melting and once a liquid phase is formed, cracks in a top brittle layer are filled and closed upon propagation and re-solidification of a liquid phase. Morphological and phase study before and after the healing event performed by electron microscopy evidence unprecedented healing mechanism based on liquid metal formation for metallic thin films. Nano mechanical testing and local probing are employed to quantify the healing efficiency in the close proximity of cracks in functional layers. Intrinsic heat source materials represent a novel, intriguing field of research and the results from this study offer an unprecedented approach towards the obtainment of self-healing metallic systems.

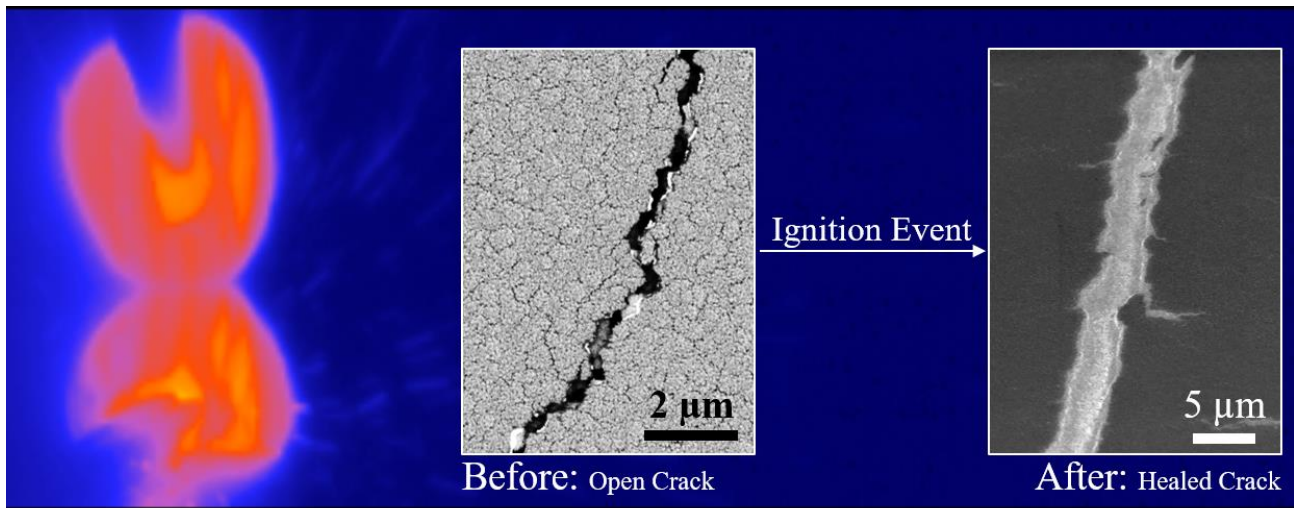


Figure 1 – Crack condition before and after healing event.