Intelligent aerospace composites with integrated nanomaterials-based sensing

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Excellent fatigue performance, high specific stiffness and strength and low density of fiber reinforced polymer (FRP) composites have led them to emerge as critical structural materials for a wide range of aerospace applications. However, structural integrity of such composites can be severely compromised by even microscale damage that might normally seem trivial, such as delamination, matrix cracking, fiber debonding or breakage, thus making it critical need to monitor the health of the structure. Identification and detection of early stages of damage formation and evolution could improve reliability and performance of composites and lead to a longer lifetime of the structure while minimizing maintenance efforts. Metal foil strain gauges and optical fiber sensors which are the most popular tools for strain sensing presently pose inherent limitations which are yet to be overcome. Hence, there has been an increased scientific and technical quest for physically stable, quick responding, highly sensitive and cost-effective strain sensing materials, devices, and techniques for applications over a broad range of strain experienced by a structure or system of interest. We pursue *in-situ* detection of damage at the earliest stages of formation and evolution in fiber reinforced composites which have come to be ubiquitous for aerospace applications due to superior damage tolerance through the embedding sensing materials in the advanced aerospace composites. We investigate *in-situ* change in electrical resistivity and Raman spectra in response to mechanical loads, correlating them with the full-field deformation and damage mechanisms using digital image correlation in conjunction with acoustic emission and thermal imaging measurements, advancing science and technology towards superior damage-tolerant and zero-maintenance structural materials.

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