Metamaterials-Inspired Smart Composite

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Abstract

Metamaterials are artificial structural materials that derive their unusual dynamic properties not just from their material constituents but more so from their engineered local features. Potential for metamaterials concepts to create multifunctional smart composites providing not just primary structural functionalities, but secondary functionalities such as passive mechanical wave manipulation, energy harvesting, and structural health monitoring was investigated. A proof-of-concept Metamaterials-Inspired Smart Composite (MISC) having CFRP face sheets on additively-manufactured polymer cores equipped with harvesting coils sandwiching a chemically etched multifunctional plate was fabricated. This plate consists of a periodic array of re-entrant cantilever beam resonators with tip-loaded neodymium magnets which act as the multifunctional kernel. MISC can isolate sensitive payloads from mechanical disturbances within tunable frequency bands. Moreover, energy sequestered by resonators could be used to harvest useable electrical power. The harvesting circuitry could double as an active control system for the resonators or as a sensing and monitoring system to detect structural defects. Experimental and simulation results from preliminary tests are discussed. Potential applications include use as structural material for equipment or vehicles used in adverse or remote locations, where maximizing energy recovery and structural awareness in addition to payload isolation is desirable.

Keywords: Metamaterials, Smart structures, Energy harvesting.

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