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STUDIES OF THE MECHANICAL PROPERTIES OF SELF-HEALING COMPOSITES IN A SPACE ENVIRONMENT

Abstract

All spacecraft are vulnerable to over 500,000 debris in low earth orbit with an impact every 14 hours, according to NASA's Long Duration Exposure Facility. Impacts cause microfractures and deteriorate the life span of spacecraft, potentially causing major malfunctions. We propose to use composite materials with integrated self-healing microcapsules as passive protection for spacecraft. Comprehensive research of self-healing composites has been conducted on Earth for a variety of future applications; however, there has been a lack of studies conducted in a space environment for potential use in the space industry. Specifically, the use of self-healing material as a passive protection against space debris has yet to be explored in space.

These composites have healing microcapsules and catalyst embedded within the resin. When microfractures are created, the microcapsules release the healing agent and rapidly solidify throughout the microfracture. However, the environmental conditions of space, including microgravity, outgassing due to the vacuum, thermal cycling, and radiation, will have an influence on this healing ability, and must be investigated.

To this end, the study will determine how effectively the composite can retain its original mechanical properties after being subjected to increasing loads. The experiment setup within the "3U" CubeSat will revolve around a three point bending flexural test. The specimens under investigation are thermosets with healing agent and without the healing agent, each with dimensions of 95 mm x 10 mm x 3 mm. A small piece of Teflon (32.45 mm x 10 mm x 0.05 mm) is embedded into each carbon reinforced composite. The created resin pocket allows us to control the location of the fractures. Load is applied by a thermal actuator, and it is measured by a qualified load cell. Strain and acoustic waves are detected by fiber Bragg grating (FBG) sensors. Bending tests will be repeated until the composite with self-healing material obtains an incurable visible crack. Preliminary investigation was conducted and the results showed that the first visible crack was obtained at Bragg wavelength shift of 6.26 nm (5173.49 microstrain) in specimen with self-curing capsules and at wavelength shift of 4.24 nm (4493.83 microstrain) in composite without curing material. The acquired parameters will be employed to cease the three point bending tests that will be performed while the CubeSat is in orbit.