Paper ID: 43533
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16th IAA SYMPOSIUM ON VISIONS AND STRATEGIES FOR THE FUTURE (D4)
Conceptualizing Space Elevators and Tethered Satellites (3)

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SURVIVABILITY OF CARBON NANOTUBES IN SPACE

Abstract

An experiment on the exposure of CNTs to a space environment has been conducted since 2015, in joint research by Obayashi Corporation, Shizuoka University, and the Japan Manned Space System Corporation, with the approval of the Japan Aerospace Exploration Agency (JAXA). The experiment uses a new experimental facility, the Exposed Experiment Handrail Attachment Mechanism (ExHAM), which is located on the exposed facility of the Japanese Experiment Module of the International Space Station.

The results of the space exposure experiments and the corresponding ground-based experiments are summarized as follows:

(1) From a comparison of the results of the space and ground-based experiments, the CNT yarn was found to be damaged on its surface mainly as a result of attack from atomic oxygen, while radiation and ultraviolet light had almost no impact.

(2) The tensile strength of both the thin and thick yarns after exposure to a space environment decreased to 65% compared to the pristine samples, even after 395-day exposure in the wake direction. This suggests the damage to the yarn due to atomic oxygen attack impacted the mechanical characteristics.

(3) The G/D ratios of the Raman spectra showed that impurities were generated during 395-day exposure in the wake direction, which coincides with the results for the tensile strength. The observed damage, the decrease in tensile strength, and the generation of impurities were correlated strongly with each other.

(4) In terms of tensile strength, the CNT yarn does not appear to be a reliable structural material for space applications such as space elevators in environments where atomic oxygen is active. In an environment with little to no atomic oxygen, such as regions at higher altitude, the CNT material can be used. Since the region where the CNT would be impacted by atomic oxygen is limited to close to the Earth's surface, i.e. up to approximately 600 km high, most of the space elevator cable, which would extend to a height of approximately 100,000 km, should not be influenced by atomic oxygen and should be able to survive.

(5) Even in an environment where atomic oxygen is active, the CNT material can survive if it is properly protected from attack by atomic oxygen. Coating it may be a suitable protection method.