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NEW ADVANCED COATING FOR TITANIUM AND CARBON/CARBON SPACE ENVIRONMENT PROTECTIVE STRUCTURES FOR CUBESATS, SUBMITTED TO ATOMIC OXYGEN EXPOSURE

Abstract

The development of long-term CubeSats mission needs to achieve reliable integrated systems able to deal with the harsh space environment during the on-orbit phase. In particular, vehicle structures are exposed to thermal cycles (TC), ultra-high vacuum (UHV), atomic oxygen (AO) erosion, high energy UV radiation and other critical phenomena, which may seriously downgrade the materials performance. The remarkable chemical stability and lightweight of carbon-based ceramic materials, such as C/C composites, promotes their employment for spacecraft Space Environment Protection Systems (SEPS) realization, thanks to the capability of keeping mechanical properties unaffected when exposed to UHV and TC. Of comparable relevance, Titanium is a lightweight, high-strength, low-corrosion structural metal, which is mainly used in alloy form for high-speed aircraft. For such reasons, C/C- and Ti-based materials are widely employed in structural parts of ISS, as well as for mini-satellites orbiting at 400-600 km. Despite their huge characteristics, these materials cannot be employed as SEPS on their own, since in LEO long-time missions the protection effectiveness may be significantly lowered due to prolonged living in oxidative environment; that necessary requires to protect the C/C and Titanium exposed surfaces from both oxidation and erosion, with particular regard to the attack of high energy AO impact. Thus, a branch of current aerospace research is focused in finding ever more effective coating materials and treatments. In this paper, a novel typology of coating based on a commercial ceramic varnish enriched by ceramic nanoparticles onto C/C- and Ti-substrates is presented. In particular, a refractory SiC pyro-paint, in turn enriched by the inclusion of Titanium and/or Silicon dioxide nanoparticles at different weight percentages, is applied on C/C- and Ti-slabs of 5 mm and 1 mm respectively thickness. The coating's development is aimed to ease the application procedure in order to reduce time and costs while keeping a high protection capability. The effectiveness of the coating process is evaluated by a thermal and morphological characterization, in order to explore the feasibility of such route for use in space operations after the exposure to LEO atomic oxygen flux by means of ground testing activities. A phenomenological modeling is also employed to approach the relationship between erosion mechanism due to atomic oxygen impact and surface energy variation induced by thermal stress; such analysis highlights the importance

of considering the combined action of different aging factors, to achieve a reliable interpretation of the space environment's effect on spacecraft structures and subsystems.