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MODELING AND EXPERIMENTAL RESULTS OF UV ENHANCEMENT EFFECT ON SPACECRAFT MOLECULAR CONTAMINATION

Abstract

Some in-orbital materials of spacecraft will degas under space environments to form molecular contamination, which will be deposited on the surface of spacecraft to degrade the performance of some sensitive materials or devices. The deposition process of molecular contamination is affected by many factors, including the type and quantity of organic materials used in spacecraft, the temperature and relative position of pollution source and sensitive surface, and the space environmental factors such as electron, proton, ultraviolet and so on. Among them, ultraviolet radiation can cause photochemical reactions or condensation of molecular contamination on sensitive surface, and results in the enhancement of contamination effect.

In this paper, a physical modeling is proposed and ground simulation test is performed to investigate the influence of ultraviolet radiation on the molecular contamination effect of spacecraft. Based on the theory of molecular multilayer adsorption, some physical processes such as adsorption, desorption, and photochemical reactions induced by ultraviolet radiation is comprehensively considerated, the relationship between the deposition amount of contamination and the time of contamination, the temperature of the deposition surface and the intensity of ultraviolet radiation have been obtained, where the deposition coefficient with or without ultraviolet radiation and the average residence time of contamination molecules are defined.

A testing equipment for molecular contamination deposition under ultraviolet radiation is built on the basis of ASTM E 1559 standard, which can realize the accurately control of some parameters and obtain the in-situ measurement of molecular contamination deposition.

Several space organic materials was used to test their contamination with and without UV radiation. The experimental results show that ultraviolet radiation has a significant enhancement effect on the amount of contamination deposition, and the effect is more enhanced as deposition temperature is decreased, It is also found that this enhancement effect increases with the increase of ultraviolet light intensity, and this is consistent with the modeling.

According to the experimental data, we have determined parameters in the physical model and the calculation model of the contamination quantity with temperature, ultraviolet light intensity and time. Eventually, the deposition coefficient with or without ultraviolet radiation and the average residence time of contamination molecules have got for different materials.

The modeling and experimental results can be used as references for the design and control of spacecraft molecular contamination.