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Smart Materials and Adaptive Structures (5)

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DEVELOPMENT OF GECKO-INSPIRED ADHESIVE MATERIALS FOR SPACE APPLICATIONS

Abstract

The challenges of capturing an uncooperative target in space are numerous, and range from approaching the potentially tumbling target, inspecting it for damage, synchronizing the motion of chaser and target as well as capturing and stabilizing it. Several research groups are currently investigating technologies and algorithms dealing with these challenges, in order to prepare missions that have the goal of an active removal of space debris, or the servicing of non-functional spacecraft on orbit.

This work addresses the challenges of docking to such uncooperative targets, investigating the usability of gecko-inspired micropatterned adhesives to be used in a biomimetic docking device. Micropatterned adhesives mimic the properties of geckos and many insects that can adhere to various surfaces and walk on walls and even ceilings based on van der Waals forces facilitated by millions of micro- and nanostructures on their feet. Synthetic adhesives based on that concept have been of high interest in the last decade: fundamental principles and manufacturing methods have been explored thoroughly. However, most of the work has been done for laboratory setups and preliminary mechanisms that work within certain constraints only. In this project, gecko-inspired adhesives are specifically developed and tested for use in the harsh environment of space, including tests according to ECSS standards in terms of outgassing in vacuum, thermal cycling, and long-term duration tests.

Furthermore, a docking device is developed based on the tested gecko-inspired adhesives that exhibits three main concepts for robust use in a docking scenario where numerous uncertainties are present: the device is flexible upon docking to be more robust for uncertain docking envelopes, including unknown relative velocity, attitude and position with respect to the target's center of mass, it can be rigidized to be able to transfer higher and more variable loads and torques in post-docking operations, and it can actively share the load between the respective gecko material elements to be able to deliver higher maximum loads.

The paper will present the manufacturing methods of the gecko-inspired adhesives and extensive test results, including the influence of vacuum, thermal cycling and long-term duration use on the adhesive properties compared to conventional micropatterned adhesives in a laboratory environment. Furthermore, the docking device equipped with the developed gecko-inspired adhesives will be presented, as well as free-floating tests of the docking device in three degrees of freedom on the ELISSA free floating test bench.