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MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Smart Materials and Adaptive Structures (5)

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BIO-INSPIRED PROGRAMMABLE MATTER FOR SPACE APPLICATIONS

Abstract

Nowadays, space structures are often designed to serve only a single objective during their mission life, examples are solar sails for propulsion, antennas for communication or shields for protection. By enabling a structure to change its shape and therefore adapt to different mission stages in a single structure, the flexibility of the spacecraft can be increased by greatly decreasing the mass of the entire system. The possibility to obtain such a structure lies in a cellular approach in which every cell is programmable to change its basic properties. The shape change of the global structure can be significantly by adding up these local changes, for example the cells length. An idea presented in this paper is to adapt these basic changeable elements from nature's heliotropism. Heliotropism is the growth or movement of an organism towards the direction of the sunlight. By changing the turgor pressure between two adjacent cells in the plant's stem, called motor cells, the stem of the plant flexes. Due to the simplicity of the principle, the movement through pressure change seems perfect for the application on deployable space structures. The design of the adaptive membrane consists of an array of cells which are inflated by employing residual air inflation. Residual air inflation uses the expansion of trapped air inside the structure when subjected to vacuum conditions to inflate the structure. A high packing efficiency and deployment reliability can be achieved by using this passive deployment technique coupled with a multiple unit membrane design. To imitate the turgor pressure change between the motor cells of the plants to space structures, piezoelectric micro pumps are added between two neighbouring cells. The smallest actuator unit in this assembly is therefore the two neighbouring cells and the connected micro pump. The cellular and multiple unit approach makes the structure highly scalable with countless application areas. This paper will outline the design idea and fabrication of the bio-inspired membrane and its application to space missions. Deployment simulations were undertaken in LS-DYNA and compared to bench test samples of vacuum inflating circular specimens. An algorithm to control the local elements in order to obtain a desired global shape will be presented as well. The paper will conclude with an overview on the REXUS 13/14 sounding rocket experiment StrathSat-R which will deploy a prototype of the bio-inspired adaptive membrane in micro gravity in March 2013.