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

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INFLATABLE SHAPE CHANGING COLONIES ASSEMBLING VERSATILE SMART SPACE STRUCTURES

Abstract

Various plants have the ability to follow the sun with their flowers or leaves during the course of a day via a mechanism known as Heliotropism. This mechanism is characterized by the introduction of pressure gradients between neighbouring motor cells in the plants stem, enabling the stem to bend. By adapting this bioinspried mechanism to mechanical systems, a new class of smart structures can be created. This paper outlines the design, simulation and testing of a smart membrane consisting of a three dimensional inflatable cellular array with fluid controlling Micro Electromechanical Systems (MEMS) based valves enabling the membrane structure to change its global shape. The valves are characterised by flexible bidirectional magnetic micro actuators, composed of a thin magnetic membrane with a central magnet feature. The membrane and magnet are both composed of a magnetic nanocomposite polymer (M-NCP) material that is fabricated by embedding rare earth magnetic powder (MQFP 12-5) in a polydimethysiloxane (PDMS) polymer matrix, which is patterned in the desired shape against a plexiglas mold via soft lithography techniques. Applied magnetic fields (and thus actuator deflections) are controlled via an applied current in planar conductive coils fabricated on flexible polymer substrates surrounding the magnetic membrane. Each cell then consists of two thin sheets of Mylar bonded together on their circumference enclosed by the MEMS valves. The overall structure is made up of a number of cellular colonies consisting of a central pressure source and vacuum outlet surrounded by multiple cells. After release in space, the trapped residual air inside the cells will deploy the cellar array through the expansion of the trapped air when subjected to vacuum. A sequence of valve operations and cellular actuation allows for any desired shape to be achieved within the constraints of the deployed array. Two different options for pressure supply to the cells will be presented, a high pressure cold gas generator and a low pressure storage unit with attached pump. This paper will give an overview of inflatable and smart structures used today, present the design and principles behind the MEMS valves and show the feasibility and shape changing capabilities with LS-DYNA and multibody dynamic simulations. The simulations are validated by on ground prototype bench tests and by two near space experiments deploying inflatable structures, the sounding rocket experiment StrathSat-R (launch May 2013 onboard REXUS13) and high altitude experiment iSEDE (launch September 2013 onboard BEXUS15/16).