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Author: Mr. Konstantin Kappe
Fraunhofer EMI, Germany

Mr. Michael Bihler
Fraunhofer EMI, Germany
Dr. Katharina Morawietz
Fraunhofer Alliance Space, Germany
Mr. Aron Pfaff
Fraunhofer EMI, Germany
Mr. Marius Bierdel
Fraunhofer EMI, Germany
Mr. Jakob Huber
Fraunhofer EMI, Germany
Mrs. Theresa Paul
Fraunhofer Alliance Space, Germany
Mr. Klaus Hoschke
Fraunhofer EMI, Germany

INVESTIGATION OF ADDITIVELY MANUFACTURED STRUCTURALLY INTEGRATED HEATPIPES FOR CUBESATS

Abstract

Over the past decade, CubeSats have been on the rise and have the potential to replace large, expensive satellites in many commercial and scientific applications. Typical applications for these standardized small satellites are earth observation constellations. With the development of small satellites come new challenges. While weight is one of the main mission drivers, the design must also be able to withstand structural loads, as well as make individual use of the limited space inside the satellite. Furthermore, the thermal design and its thermal stability is of great importance for the functionality of the electronic and optical components.

For these demanding requirements the design freedom of additive manufacturing (AM) technologies enables new possibilities. Topology optimization algorithms allow the optimal utilization of the design space at a given load. However, due to the development of more powerful electronic components in nanosatellites, the power and packing density is constantly increasing. In order to keep the temperature inside the satellite within the operating limits, the direct integration of a heat pipe, a two-phase heat transferring device, into the curved topology optimized structure is investigated. The complex capillary structure (wick) inside the heat pipe is essential for the fluid cycle under low or zero gravity conditions and thus the effectivity of heat transport. The various design approaches such as axial grooves, porous sintered and mesh structures differ in capillary pressure, as the driving force, and flow resistance. With the great design freedom, the variation of manufacturing parameters and the combination of different structures, AM offers a wide range of possibilities for the design and optimization of the capillary structure. At the same time, the boundary conditions of the used material and working fluid as well as the manufacturing, cleaning and filling process have to be considered. The embedding of the heat pipe in the structure usually requires curvatures, which also affect the manufacturability and function.

In order to investigate structural integrated heatpipes, various concepts are designed and integrated into complex test structures. The test samples are additively manufactured from Scalmalloy©, a high strength aluminium alloy, by laser beam melting and filled with acetone as work fluid. The heatpipes are examined in thermal experiments. The comparison reveals yet challenges of the different structural concepts and manufacturing characteristics. However, the general feasibility is demonstrated and first promising integrated heatpipes are fabricated.