IAF SPACE POWER SYMPOSIUM (C3)
Advanced Space Power Technologies (3)

Author: Mr. Benjamin Grzesik
Technische Universität Braunschweig, Germany, b.grzesik@tu-braunschweig.de

Dr. Guangyue Liao
TU Braunschweig, Germany, g.liao@tu-braunschweig.de
Mr. Linus Froböse
Technische Universität Braunschweig, Germany, l.froboese@tu-braunschweig.de
Mr. Daniel Vogt
Technische Universität Braunschweig, Germany, d.vogt@tu-braunschweig.de
Mr. Stefan Linke
Technische Universität Braunschweig, Institute of Space Systems, Germany, stefan.linke@tu-braunschweig.de
Prof. Arno Kwade
Technische Universität Braunschweig, Germany, a.kwade@tu-braunschweig.de
Prof. Enrico Stoll
TU Braunschweig, Institute of Space Systems, Germany, e.stoll@tu-braunschweig.de

INTEGRATION OF ENERGY STORAGE FUNCTIONALITIES INTO FIBER REINFORCED SPACECRAFT STRUCTURES

Abstract

One of the ongoing challenges in space travel and also in the age of growing e-mobility is energy storage. The operational ranges of spacecrafts or electric cars as well as operational usability is strongly dependent on the capacity of the energy storage, which is usually constrained by mass and volume limitations of the vehicle. For example, large communication satellites consist of battery mass from 6% to 9% related to the dry mass. This amount increases for smaller satellites like CubeSats up to 13% without accounting wiring harnesses and subsystem volume. Thus, a system can benefit from a reduction in mass and volume by combining multifunctional use of the components and materials. In the presented research energy storage is integrated into lightweight carbon fiber materials. These materials have the clear mass advantages compared to metal structures. In addition, they have very low thermal expansions that can reduce thermal stresses during the operation of a satellite. Fiber composites or laminates consist of two components essentially - fibers and matrix. In typical laminates, the matrix content, which is typically resin based, is 30% to 40% of the component volume that can be substituted with novel solid-state battery materials. Latter have the advantage that they have nearly similar physical properties compared to normally used resins and are also able to store energy electrochemically. Thus, about 25% of the volume can be used for electrochemical energy storage without compromising structure integrity. To reach such electrochemical functions anode, cathode and separator materials have to be infiltrated into the host structures. Using the developed recipes and a component thickness of 5 millimetres an energy amount per component area of 1130 Wh/m^2 - can be reached depending on the used battery active material. This paper will give an overview how fiber composite materials, which are increasingly being used in lightweight construction processes, can be combined with energy storage materials to be used in spacecraft structures. Furthermore, the paper will summarize the already performed research on this topic at Technische Universtät of Braunschweig. An estimation of the expected performance is carried

out. The initial material evaluation and the manufacturing process as well as mechanical and electrical result will be discussed. Finally a use-case application in form of conceptual design for a CubeSat is shown and an outlook of the following work to raise the initial Technology Readiness Level (TRL) up to four will be given.