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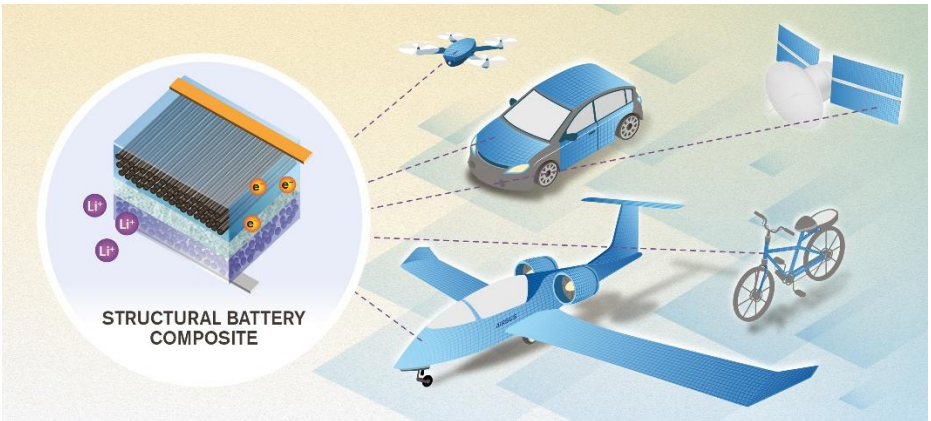
Leif Asp
"Coupled electro-chemo-mechanical processes in structural battery composite materials"

Dr Leif Asp joined Chalmers University of technology as professor in lightweight composite materials and structures at the at the Department of Mechanical Engineering in 2016. He is currently, the Director of Chalmers' Area of Advance in Materials Science and holds a position as visiting professor at the Department of Aeronautics at Imperial College London. Dr Asp's research has largely focused on efficient design methodologies for carbon fibre composite transport applications. The research relies on more than thirty years' experience in damage tolerance modelling, design and certification methods for aircraft composite structures. Since 2007, Professor Asp has been leading research activities on multifunctional composites. In particular, the research group performs research on structural battery composites, a material that can simultaneously store electrical energy and carry mechanical loads. The work comprises material development, modelling and characterisation, ranging from mechanical and electrochemical characterisation and multiphysics modelling of constituents to cells and multi-cell structures.

Structural battery composites utilise carbon fibres in their electrodes. In the negative electrode, often referred to as the anode, carbon fibres distributed in a structural electrolyte act as active electrode material, i.e., host of lithium, current collector, and reinforcement. In the positive electrode carbon fibres coated with a lithium iron phosphate (LFP) rich coating embedded in a structural electrolyte constitute a structural cathode. Here, the carbon fibres in the positive electrode acts as scaffold for the LFP, current collector and reinforcement. The two electrodes are separated by a thin cellulose fabric. During charging following a red-ox reaction at the fibre / structural electrolyte interface lithium enters into the carbonaceous structure of the fibre. As the lithium inserts and coordinates with the carbon atoms, the fibre expands approximately 1 % along its axis and 7 % in the radial direction. This volume change causes extensions of the composite ply, i.e., the electrode, that must be considered in the laminate design. In addition, the elastic moduli of the carbon fibre vary with state of lithiation, where the modulus in the transversely isotropic plane doubles for the fully lithiated carbon fibre compared to the pristine or delithated one. At the same time, the longitudinal modulus is reduced by 12 %. These volume changes and change in elastic moduli of the fibres affect the internal mechanical stresses in the carbon fibre electrode. In this talk, the influence of state of lithiation on the multifunctional performance of the negative structural battery full cell will be discussed. Furthermore, the coupled electro-chemo-mechanical processes will be discussed and an example of the effects of mechanical stresses on the electrical potential of the structural battery will be reviewed.



A schematic of the structural battery and its potential applications (Chalmers university of Technology, 2021)