Integrated Smart and Multifunctional Materials for Aircrafts

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Abstract: New materials with superior properties are the basis to exceed existing techno-logical barriers and to explore new fields of application. Especially composites as multiphase materials offer the possibility to influence their properties or to add even new functionalities by a proper choice and combination of the different phases. The ideal basic material for "smart structures" possesses both functional characteristics as well as load-bearing capabilities. Unfortunately, there is yet no existing material known that unites all of these characteristics in a sufficient manner. The assembly of a multifunctional material system is therefore realized by combining functional materials with a primarily load-bearing component. Fiber composites are well-suited for the purpose of assembling a smart structure, since the functional components can be inserted during the production process and, thus, become an inherent part of the structure. Additionally, the specific requirements and characteristics of the functional materials can be accounted for by the several production options for composites such as selection of the fiber/matrix material and the layup of the structure. Hence, the smart structure is designed and manufactured as a whole with embedded smart components including its supporting infrastructure of, e.g., lead wires, electrodes and terminals for power supply.
Sensors and actuators based on multifunctional materials are a substantial component of smart composite structures. Such multifunctional materials also called "smart" or "intelligent", are energy converters or transducers that respond in a technically usable manner to an external stimulus. The most widely employed types respond to an electric, thermal or magnetic field with a change in their mechanical properties. Well-known representatives are piezoelectric materials (load/deformation response to an electric field), shape memory alloys (temperature dependent load/deformation) as well as electro- and magnetorheological fluids (influence of shear transmission in an electrical or magnetic field respectively). Typically, the underlying actuation mechanism is caused by a microscopic reconfiguration in the material and operates in both directions. A change in the mechanical characteristics due to external loads can be detected and, thus, allows for sensor use also. The reliable subsequent treatment and structural integration of the usually very sensitive materials is however connected with some complexity and risk. The goal of our research activities is therefore to develop multifunctional material systems to enable the setup of reliable and reproducible smart structures that can be successfully applied in industrial production.

Biosketch: Dr.-Ing. Peter Wierach is a Deputy Director at the Institute of *Composite Structures and Adaptive Systems* since 2012 and, within the latter, a Head of the Department of *Multifunctional Materials* since 2009. The same year, he got his PhD in *Smart-Structures Technology* on "*Development of Piezocomposites for Adaptive Systems*" from the Technical University of Braunschweig (Germany). In parallel to his professional activity, Dr. Wiereach has a University teaching position for *material technology* at a private University of Applied Science in Göttingen since 2007. He was also a Deputy Head of the *Adaptive System* Department of the above institute from 2003 to 2008. Dr. Wierach is a Scientist and project manager at the Institute of *Composite Structures and Adaptive Systems* of the German Aerospace Center (DLR) - Braunschweig since 1998. His research interests are in *multifunctional materials and material systems*, *actuators and sensors development*, *characterization of piezocomposites*, *manufacturing technologies for piezocomposites*, *morphing structures*, *active helicopter technologies*, *Active Twist Blade (ATB)*, *active noise and vibration control*.