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NEW APPROACHES FOR THE MANUFACTURING AND CHARACTERIZATION OF SMART STRUCTURES MADE OF FIBER REINFORCED PLASTICS

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Summary: This work deals with the manufacturing and characterization of smart structures made of fiber-reinforced plastics (FRP) and active elements like shape memory alloy (SMA) wires or piezoelectric transducers. Manufacturing processes for the structural integration of these elements as well as methods for their characterization are presented.
Active elements like SMA wires and piezoelectric transducers enable new functionalities in various areas of application. SMA wires show outstanding actuation performance (up to 6% strain) that allow for active shape change in aircraft wings, air inlet vents or car spoilers. On the other hand, piezoelectric transducers are highly sensitive to acoustic waves and therefore suitable for non-destructive testing and the realization of sensor networks for guided wave structural health monitoring (SHM) systems. However, the lack of robust manufacturing processes that offer easy and repeatable integration of active elements and the deficiency of applicable characterization methods that facilitate the design of active components, impede the breakthrough of these smart structures.
These circumstances are the starting point for this study which promotes the development of modular manufacturing methods which do not only feature reproducibility and robustness but also are applicable to conventional FRP production processes (RTM, Autoclave). A common challenge in the manufacturing of smart structures is the assurance of adequate mechanical coupling without the deterioration of the mechanical properties of the structure. The study investigates this challenge and proposes methods for the optimization of the interface in terms of load transfer and acoustic coupling respectively. A standardized, modular concept for the integration of active elements in various fiber-reinforced plastics is finally presented as an outlook.
Besides the new manufacturing concepts, the study proposes standardized testing methods for describing not only the active element itself but also the smart structure as a whole.
Concerning SMA, a method for the determination of maximum deflection and stress as a function of structure stiffness is presented. Regarding the realization of SHM systems, a closer look is taken at the dispersion and attenuation of guided waves in FRP.