Mechanical and dielectrical strength of fiber-reinforced composites with modified interphases

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Power transformers and switchgears are key components made of high-performance composites used in power grids. Their availability and robustness have a decisive influence on the reliability and profitability especially for the future expansion of power grids. Their mechanical but also dielectric composite strength is strongly determined by the fiber-matrix interphase as the origin of micro-scale damage. The objective of the project is the development of approaches to reduce stress concentrations in the interphase in order to increase the durability of composite structures. This is achieved by fiber surface modification for a gradation of the interphase to avoid the distinct stiffness difference occurring between fiber and matrix. Experimental and simulation studies have been conducted at both micro and meso scales, utilizing single fiber model composites and unidirectional (UD) composite plates made from tailored glass fibers produced via a pilot spinning line. The characterization of the interphase stiffness by nanoindentation revealed the strong influence of sample preparation and measuring parameters on the results obtained. Studies of single fiber pullout tests were conducted to analyze interphase parameters and the damage process during pullout, considering factors like fiber diameters and embedment lengths. For the simulation of the experiments, a generalized variant of a traction separation law was introduced. Additionally, numerical modeling of UD composites with random fiber packing and fixed fiber volume fraction demonstrated how graded stiffness affects transverse mechanical properties compared to uniform-stiffness interphases. A systematic study on the dielectrical strength of UD composites by varying material parameters as well as manufacturing processes is carried out in order to build up fundamental knowledge about the mechanism in the interphase that could lead to dielectrical break down. The project addresses the need for new methodologies and validation tools for interphase optimization required in all composite market sectors to gain knowhow in the complex field of interphase formation, their stress transfer capability and damage behavior.

The GRADIENT project will be presented by a talk and a poster. The collaborative research combines an international and multidisciplinary team from Germany, Latvia, and Sweden. The project's funding is provided by the corresponding national financiers:

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