SUBPROJECT 10: In-situ measurements and algorithms for complex 3D deformations of I-FRC

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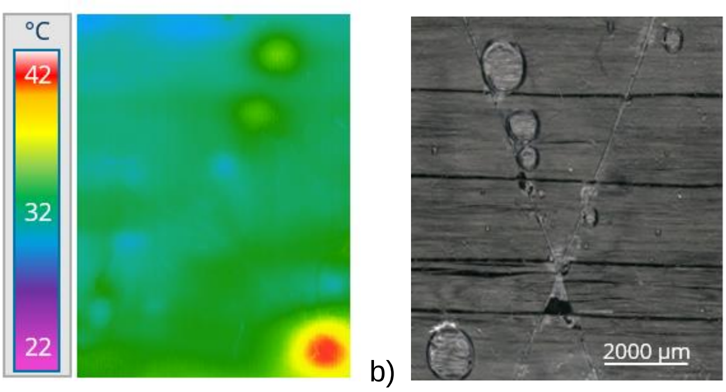
Motivation

Fiber Rubber Composites (I-FRC) exhibit complex deformation behavior that are crucial to understand for optimizing their application in various engineering fields. Currently, these deformations are measured using external devices such as camera technology and Digital Image Correlation (DIC). While effective, these methods require controlled environments and extensive setups, limiting their practicality for real-time monitoring. The challenge remains to develop in-situ measurement techniques that enable the system to function autonomously. Achieving this would allow real-time, direct data acquisition and analysis within the material or structure, without relying on external instrumentation. Such advancements would significantly enhance our ability to monitor and respond to deformations as they occur, leading to improved material performance and safety in practical applications.

State of the art and previous research

The significance of flexible, intelligent structures such as I-FRC is steadily increasing. Recent research in this field includes numerous applications in areas such as soft robotics, aerospace, biomimetic applications and medicine [1-3]. Hence, the long-term stability of the structures, especially under conditions that no longer correspond to the ones in a laboratory environment is becoming increasingly important [4,5]. The Multi-DIC method in particular is a common tool for analyzing the deformation of I-FRC. In the 1st cohort, a method for 360° investigation of the overall deformation behavior using 12 cameras was established [9]. In the 2nd cohort, a camera-sensor system with 4 camera pairs was used to investigate the deflection of an actuator with particular focus on localized damage phenomena [10]. These methods enable the spatially resolved characterization of the deformation behavior for complex I-FRC elements and to a limited extent the development of damage. The development of in-situ measurement techniques for I-FRC that enable autonomous system functionality remains an unfulfilled goal. The evaluation of complex deformations in I-FRC requires advanced algorithms capable of processing and analyzing data directly from the material or structure. These algorithms must handle the intricate patterns and behaviors exhibited by I-FRC under various conditions. Therefore, further research is essential to create these in-situ measurement systems and develop robust algorithms for evaluating complex deformations. This would enable autonomous, real-time monitoring and response, significantly enhancing the performance and reliability of I-FRC in practical applications.

a) b)


Damage assessment of I-FRC by means of a) lock-in thermography and b) microscopy

Scientific questions and project objectives

The primary objective is to develop robust in-situ measurement techniques for the complex deformation of I-FRC. This involves establishing foundational principles for understanding these deformations and validating the new in-situ methods against external measurement systems developed by previous cohorts, ensuring accuracy and reliability in real-world applications. The main basis of the study are structures that are developed together with SP 2, 7 and 8.

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