Chair of Carbon Composites
TUM School of Engineering and Design
Technical University of Munich

Material Behavior in Additive Processes

We advance extrusion based additive manufacturing for composites

We research the material behavior along the entire process chain of polymer-based extrusion additive manufacturing from new material combinations to the post-processing of printed structures. Our goal is to use additive manufacturing to advance and flexibilize the manufacturing of and to integrate functions into composites. With the help of high-precision printers with minimal output quantities up to robot-based large-scale systems, we bring our material research into practical application.

Research on new materials and material combinations

In order to additively process materials we determine and control their behavior. This includes both newly developed material combinations and materials that are initially only used in classic manufacturing processes. Existing materials can be examined by means of rheological, thermal and mechanical characterization and adapted for new additive processes. New material combinations combine the advantages of different material properties and serve to simplify and improve processes. We thus create new possibilities for additive manufacturing of components.

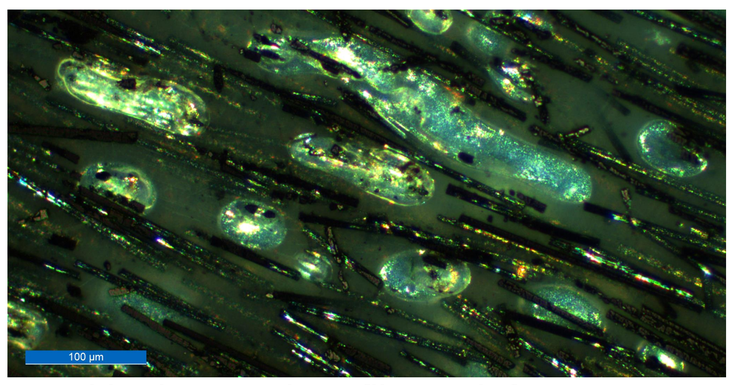

Fig.1: PAEK with short carbon fiber reinforcement and trapped gas bubbles

Integration of fibers

Polymers reinforced with both short and continuous fibers can be printed. While short fibers improve printability, their positive effect on mechanical properties cannot compete with continuous fiber reinforcement. Thus, we specifically address challenges associated with the integration of continuous fibers such as fiber architecture, the bond between fiber and matrix, and porosity. This research serves as a basis to integrate continuous fiber reinforcements along load paths allowing for complex and lightweight structural components. In addition, we study the use of these fibers as sensors for structural health monitoring.

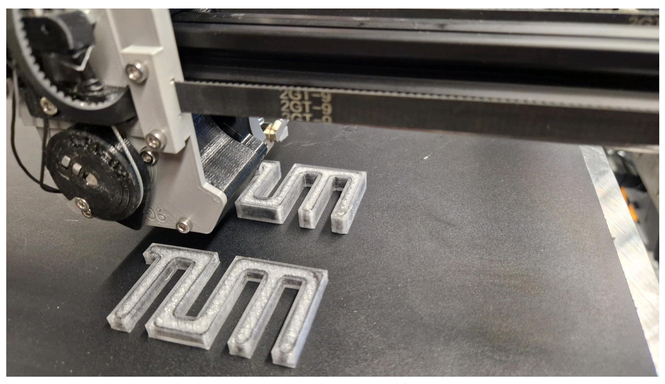
Fig.2: Printing of PP with partial endless carbon fiber integration

Interactions between material and process

Material properties in additive manufacturing strongly depend on the applied process technology and the scale of the process. We research the influence of the printing process on the material, from micro to macro structure, both within and in between layers. We transfer this knowledge into adapting and improving processes for new materials such as integrating selective layer heating to improve bonding in between layers for large scale additive manufacturing. A special focus lies on the research of the behavior of short and continuous fibers in the printing process.

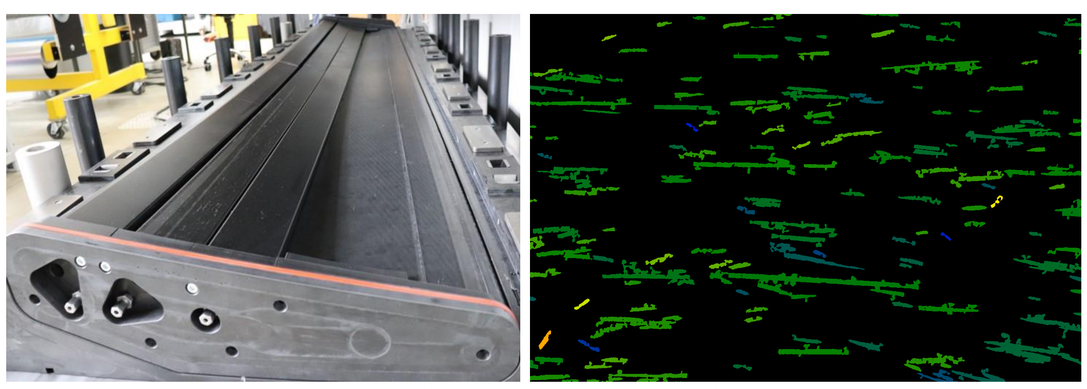
Fig.3: Printed RTM-Tooling from PAEK with 40% short carbon fiber (left); process induced fiber orientation (right)

Post-Processing, repair and recycling

The layered structure in extrusion-based additive manufacturing requires subsequent process steps depending on the application. To this end, we develop automated processes for optimizing the component surfaces in order to use this for demanding applications such as toolmaking. To extend the service life of existing components, we are researching repair and functional extension by means of additive manufacturing. We aim to generate a circular material cycling reprocessing already printed structures. An important aspect is to understand how the material properties and behavior change with repeated processing.

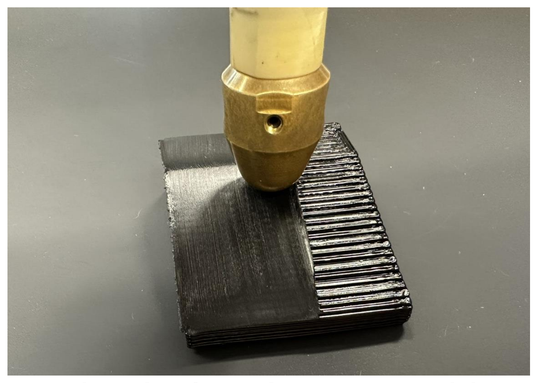
Fig.4: Thermomechanical surface smoothing of printed part

For further information and contacts: