AUTOMATED ADDITIVE MANUFACTURING OF SHORT FIBER PREFORMS WITH TAILOR-MADE PROPERTIES

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ABSTRACT

Additive Manufacturing is a rapidly growing technology with unique potential for the production of short fiber preforms with tailor-made functionalities and complex 3D-geometries that cannot be provided by conventional manufacturing technologies. The state of the art Additive Manufacturing processes are usually based on powders, liquids or molten polymer-strands and thus have isotropic characteristics. In order to exploit the outstanding properties of high-performance fibers such as carbon fibers and biopolymer fibers, ITM is developing a technology for the production of anisotropically structured short fiber preforms, which is implemented in two fully automatic and additive laboratory systems. Promising application fields for these preforms are Ceramic Composites and fiber-based scaffolds for Tissue Engineering.

In order to design a high-performance preform for Ceramic Composites, it is necessary to set the orientation of the short fibers, the density and the geometry of the preform in a defined way. To ensure a tailor-made short fiber preform a preforming plant with four working stations has been developed. The fully automated technology enables the manufacturing of high-performance short fiber preforms with variable fiber length with defined orientation in in-plane- as well as out-of-plane direction and combines the directed fiber application with a resin application and a curing step. The preforms are used to process C/C-SiC ceramics by using liquid silicon infiltration technology which shows increased bending strength and thermal conductivity compared to the state of the art short fiber reinforced C/C-SiC ceramics with an isotropic fiber orientation. These C/C-SiC ceramics have a high potential for application in high-performance brake discs, clutches and gas turbine fans.

To cover a broad range of high-performance materials, extensive research on the processability of flexible biopolymer fibers was conducted. An additive manufacturing process was developed based on these insights and well-tried and tested for chitosan as well as for silk fibroin short fibers. Along with the development of biocompatible binder systems, three-dimensional scaffold structures with interconnected pores, predefined pore-sizes and pore-size grading suitable for cell ingrowth and cell differentiation and thus for applications in regenerative medicine were developed.

The developed process technologies on the basis of automated additive manufacturing technology demonstrate the outstanding suitability for the development of tailor-made short fiber preforms for high-performance ceramic composites and fiber-based medical products.