Friedrich-Alexander-Universität Erlangen-Nürnberg

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Modified Polymers in Thin-Wall Applications

Motivation

Increasingly complex requirement profiles are the driving force behind the development of efficient fabrication techniques for components with multicriterial functionalization. This includes components made of composite materials and material composites with multi-scale geometric elements that are functionalized in terms of mechanics, fluidics (Fig. 1) and reactivity as well as electrical and thermal properties (Fig. 2). In order to be able to process the highly modified material systems with optimized chemical and physical material structures, integrated and shortened process chains must be set up specifically for this purpose. The main challenges in the development and implementation of such processes are scalability in terms of output and component size, while at the same time taking sustainability into account with regard to existing material cycles and zero waste production.

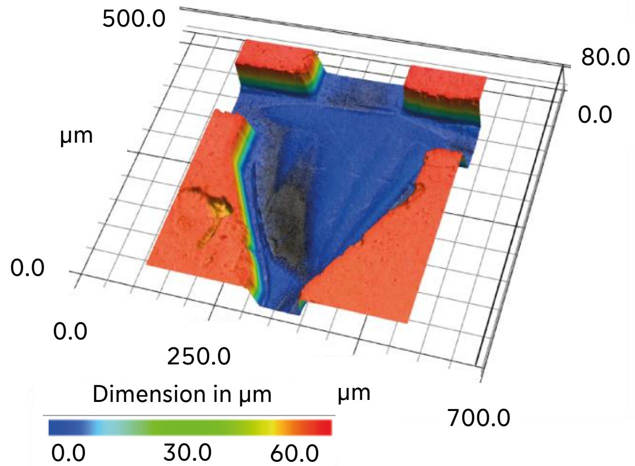

Fig. 1: High aspect ratio (width-to-depth) channel- structure on a thin-walled substrate

Application

In addition to thin-walled housings for processors or electric motors in compacted electrical circuits, modified polymer systems are also applied in thin-walled thermoplastic bipolar plates for redox flow batteries or fuel cell systems. By adding the appropriate filler, high and efficient heat dissipation with simultaneous electrical insulation or high electrical conductivity can be achieved.

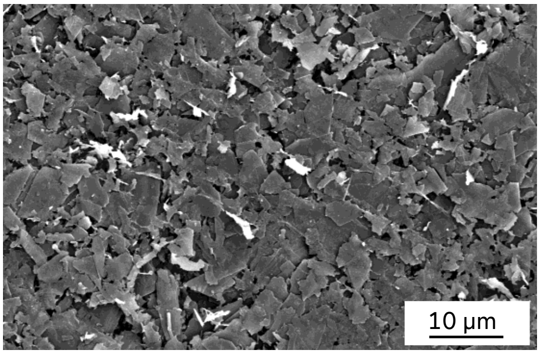

Fig. 2: Surface of a polypropylene matrix filled with 62 vol.-% of graphite particles and molded into a 0.5 mm thick plate

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Research focus

Particularly with small component dimensions, high filler grades have an enormous influence on the flow behavior of the polymer melt. The use of modern process strategies enables the highly modified material systems to be processed into functionalized, large-area, thin-walled and planar-structured components within the framework of processes suitable for mass production. These include variothermal process control to maintain the flowability of the material during molding and the use of multilayer systems with the aid of liquid structures in extrusion, thermoforming, hot embossing or injection molding processes. In particular, the interaction between the underlying material properties (e.g. viscosity, electrical conductivity) and the resulting component properties (e.g. dimensional stability, component mechanics, sealing) has to be taken into account.

Main research results

An adapted injection compression molding process with dynamic mold temperature control allows temperature and pressure to be controlled and shear to be indirectly influenced during the mold filling process (Fig. 3). Based on analytical and experimental research on the material behavior of highly filled polymer materials, the required time-, temperature-, pressure- and shear-conditions during the process can be optimized to enable the fabrication of planar structured components with the highest possible dimensional accuracy and aspect ratios while simultaneously optimizing physical properties like thermal or electrical conductivity (Fig. 4).

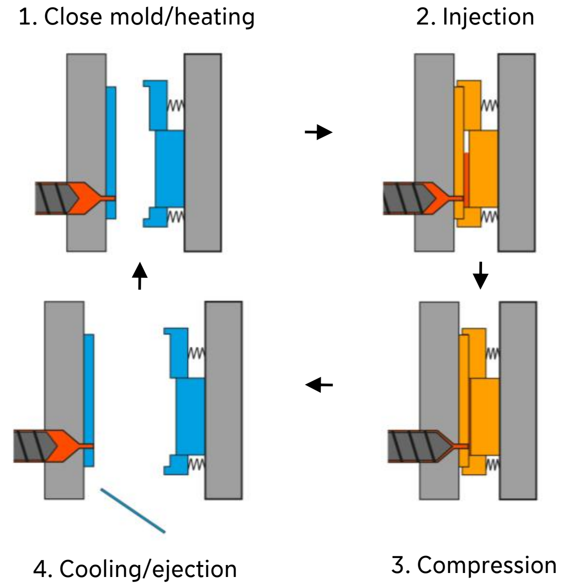

Fig. 3: Injection compression molding process with dynamic mold temperature control

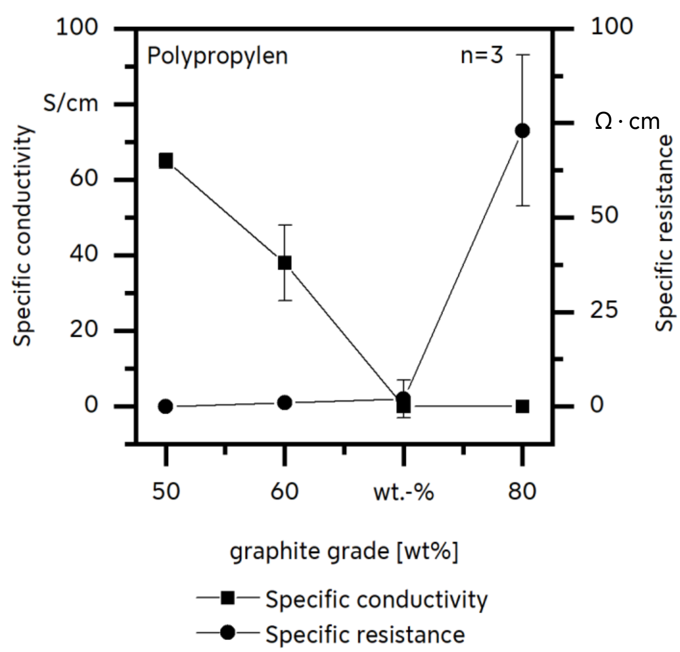

Fig. 4: Electrical conductivity of highly filled polymer graphite compounds

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