Extrusion-based AM has great potential for novel industrial applications in the context of Industry 4.0, combining freedom of design (e.g. bionic structures), flexibility of production (small series), product individualization and recyclability.

However, for the successful industrial implementation of these technologies, several challenges still need to be overcome: limited material options, difficulty of combining different materials, strong dependency of final properties on printing strategy and parameters and long manufacturing time.

At Fraunhofer ICT, we are working on solving these problems, developing new materials and processing technologies for thermoplastic-based AM.

Fields of research at ICT:
- Bio-based polymers
- Glass-/-carbon-fiber-reinforced high-performance thermoplastics
- Tailored functional nanocomposites (e.g. for thermal, electrical, antibacterial properties)
- Recycling material
- Material optimization for AM (pellets and filaments)

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**Formulation development**

Experts select thermoplastic matrices and suitable (functional) fillers according to the application. Generally, any commercially available plastic can be used as a matrix material for extrusion-based AM.

Biobased and biodegradable polymers (e.g. PLA, PHB) are produced, modified and optimized for AM processes. High-performance thermoplastics (e.g. PEEK, PPS, PPSU) reinforced with glass or carbon short fibers are suitable for demanding applications where traditional engineering thermoplastics cannot be applied.
Metals or carbon-based materials can be used as fillers, for example in electrically conductive composites. The selection depends on the required conductivity and the specific application: for example, metals cannot be used in a corrosive environment. Processability, and especially the melt viscosity of the composite, also plays an important role.

Besides traditional particles for functionalization, nanomaterials can also be used. Carbon nanotubes (CNTs) enable electrically conductive composites with considerably lower filler concentrations than can be achieved with metal fibers or conductive carbon black. As a result, the viscosity of the melt and the mechanical properties of the composite compared to the matrix material are less strongly affected.

Process development

The target properties of produced parts depend on the composition of the composite as well as the complete processing chain, from the compounding of the composites to the manufacturing of the parts. Our specialists monitor the entire process and optimize technological and economic aspects of both the material composition and the production process.

Equipment available at Fraunhofer ICT

Technical equipment available for formulation development ranges from various small-scale mixers, kneaders and extruders through to pilot plant compounding lines in which the composite is supplied as granules. A filament extrusion line for the production of thermoplastic filaments with diameters of 1.75 mm and 2.85 mm is also available.

The equipment available for process development in additive manufacturing includes the extrusion-based additive manufacturing processes Arburg plastic freeforming (APF) with a 2-component freeformer and one and two component fused filament fabrication (FFF) machines.

In addition, accompanying technologies such as plasma processes for the pre-treatment of printable substrates, or microwave processes for the post-treatment of additively manufactured components, as well as the accompanying characterization of materials and components, are provided by the test laboratory.

Our offer

We offer our customers services ranging from basic investigations and feasibility studies to process engineering implementation.

– Feasibility studies
– Benchmark testing (APF, FFF, injection molding)
– Formulation development (filaments, granules)
– Determination of suitable processing parameters
– Consultancy in process and component design
– Characterization of materials and components

4 AM machine at Fraunhofer ICT.
5 Fracture surface of PPS-GF40 filament.