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Injection Moulding Quality in Polymer 3D-Printing

High-quality components with optimised mechanical properties and excellent surface quality from a 3D-printer

Ever shorter product life cycles and a trend toward individualised products demand increasing flexibility for manufacturing and developing new products. 3D-printing of highest quality plastic parts ensures the highest level of flexibility for the industry. Conventional 3D-printers may offer the possibility to produce complex prototypes, however, they merely deliver an approximation to a realistic representation of the shape. The aesthetic and in particular the mechanical product characteristics, such as for example the surface roughness or the impact strength and flexural strength, still remain significantly behind those of injection moulding parts.

Additive manufacturing processes (AM processes), including 3D-printing, do not only realise the geometry but simultaneously also the material properties during the manufacturing process. Today's AM processes are able to transform 3D CAD data directly into a physical component.

3D-printed polymer structures

Objective

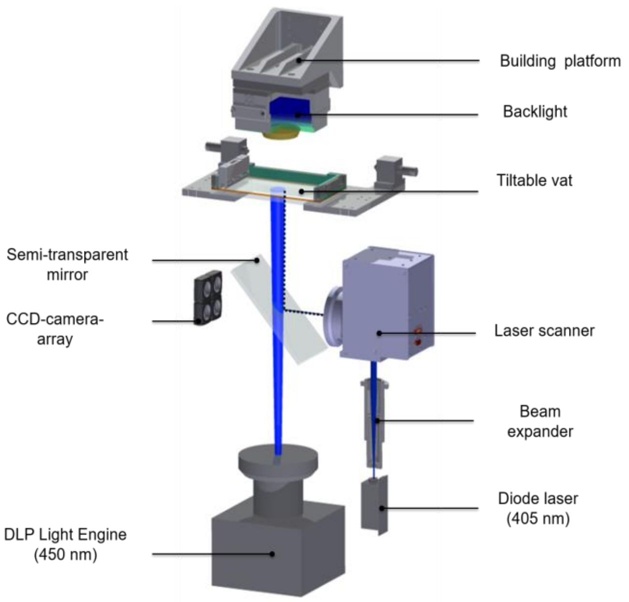
The TU Wien research group headed by Prof. Jürgen Stampfl specialises in the development of new materials and complementary 3D-printers. In addition to the processability of high-viscosity plastics and ceramic slips, the focus is on optimising the surface quality and mechanical properties. The aim is to be able to produce highly complex 3D geometries in-house without wasting resources – that is without producing any waste. This will enable the production of prototypes, single items and small lots that match the properties of products manufactured according to conventional manufacturing methods. Design and functional errors may therefore be identified as early as possible in the process chain; later changes and related costs are thus avoided. The focus is on the processing of high-viscosity and impact-resistant polymers that are generally used in industrial injection moulding (e.g. ABS) and that have not been available for 3D-printing up to now.

Approach

The 3D-printers developed by TU Wien are based on a proprietary stereolithography process (SLA), i.e. hardening through light. This enables the processing of tough polymers, ceramics and biodegradable polymers among others. A photosensitive resin is used forming a solid polymer when exposed to light.

The printer uses the dynamic mask exposure technology by means of DLP projection (Digital Light Processing), which allows for adapting the wave length. While up to present the entire structure to be hardened was exposed in one area simultaneously, a new development enables the combination with a laser that is able to scan the surfaces instead or in addition to the DLP projection. The main advantage of SLA over other AM processes is due to the high resolution, which is even further increased through the laser.

Up to present, merely thermosetting plastics such as (meth)acrylate and epoxides could be processed. These are, however, comparably inelastic and thus inapt for many applications. By modifying the resin system it is now possible to achieve the thermo-mechanical properties of polymers used by the industry (e.g. ABS) and match or even exceed their impact strength. This research of TU Wien was funded by the Horizon 2020 EU programme with the project number 633192 (ToMax).

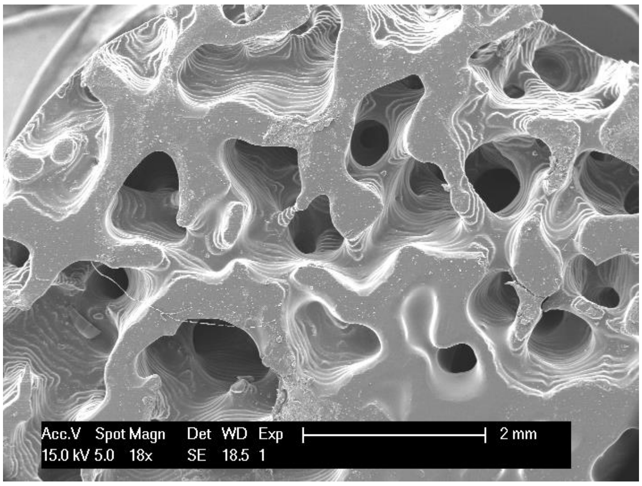


3D-printer developed by TU Wien

Results

In addition to different ceramics such as aluminium oxide, zirconium oxide, bioglass® and tricalcium phosphate, the SLA system developed at TU Wien is the first system to allow for the flawless printing of high-viscosity polymers. The system is able to realise cellular structures with a wall thickness of 100 µm at a resolution of <2 0µm. High-strength components that simultaneously feature a high elongation at fracture (e.g. snap fits) and, similarly, rubber-like parts (e.g. absorber elements) may be produced. Compared to conventional SLA materials, the impact strength of 40 kJ/m² and the elongation at fracture of 40% as well as the heat resistance have been increased considerably.

This new technology represents a promising alternative to conventional polymer injection moulding for manufacturing components under high mechanical stress. At the same time it offers greater geometrical design freedom and higher resource efficiency. The SLA system used provides for a construction volume of 144 x 90 x 160 mm and



Scaffold - cellular polymer structure

allows for creating components with a lateral resolution of 15 µm and a layer thickness between 15 and 100 µm.

Your benefits

- The technology developed by TU Wien enables the manufacturing of precision components with a high resolution
- Components from 3D-printable polymer materials with increased impact strength
- High manufacturing speeds by using the DLP procedure
- Resource-efficient manufacturing of complex geometries with highest quality directly from CAD files
- Material, energy and cost-efficient realisation of fully functional single items
- Manufacturing of different single items or small lots in tool-free parallel production
- Manufacturing of parallel products with excellent mechanical properties – comparable to injection moulding series production but without the respective tooling costs

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