3D-printable materials: Design principles for strong and tough polymers, ceramics and metals

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Additive manufacturing (AM) has developed into a promising technology for various engineering applications and provides advantages over conventional manufacturing methods like casting or milling. Nevertheless, 3D-printable materials are still fighting to meet the demanding requirements of many applications in engineering and biomedicine.

The presented work will give an overview about general toughening concepts for polymeric, ceramic as well as metallic 3D-printable materials and give insight into the interconnections between the most relevant thermomechanical properties (strength stiffness, toughness, heat deflection temperature) for these materials.

Most AM materials have their origin in traditional manufacturing (metals for casting and CNC-machining, polymers for injection molding, …) and only partially fulfill the requirements of dedicated AM materials: Processing based on selective laser melting/sintering or photopolymerization, respectively, put specific demands on the utilized materials if the mechanical properties of the final part should be optimized. With the significantly increased consumption of 3D-printable materials, the necessity to use raw materials which are specifically optimized towards being used in AM is steadily growing and a detailed scientific investigation of such materials is required.

Since AM allows not only to define the shape of a part, but also enables the variation of material properties within the part (gradient materials, digital materials, …), new routes for a sound scientific investigation of 3D-printable materials are available. Several examples of recently developed 3D-printable materials (metallic high-performance alloys, strong and tough photopolymers, high-strength ceramics) will be presented and will illustrate this approach.