Fraunhofer Additive Manufacturing Alliance

From data straight to highly complex products

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Summary

Additive manufacturing is known as 3D printing in popular science. It refers to a relatively new group of manufacturing techniques with unique properties and possibilities compared with conventional manufacturing technologies. The Fraunhofer Additive Manufacturing Alliance currently coordinates 17 Fraunhofer institutes working on additive manufacturing. It covers the entire process chain: the development, application and implementation of additive manufacturing techniques and processes as well as the relevant materials. This chapter provides an overview of the technologies, applications, particular opportunities and further goals of applied research in the area of additive manufacturing within the Fraunhofer-Gesellschaft. We make particular mention of mesoscopic lightweight design, biomimetic structures, high-performance tools for hot sheet metal forming, ceramic components, printable biomaterial, large-size plastic components, integrating sensory-diagnostic and actuator therapeutic functions into implants, and three-dimensional multimaterial components.
10.1 Introduction: history of additive manufacturing

Additive manufacturing (AM), often referred to as 3D printing in popular science, is a comparatively new group of manufacturing techniques with unique properties and possibilities compared to conventional manufacturing technologies we know today. During the early days of additive manufacturing in the 1980s, mainly polymers were being processed. Today, however, metals and ceramic are also being used. Until now, the technology for all of the additive manufacturing techniques has been based on a layer-by-layer build-up of components. Originally, additive manufacturing techniques were used for quickly producing prototypes and were referred to as such (“rapid prototyping”). Now, however, further development has made the direct manufacturing of serial components and end products (“direct digital manufacturing”) possible.

Additive manufacturing techniques are primarily employed for three reasons:

- Individual item and short-run batch production can often be more economically attractive when molds and tools are avoided.
- Fewer manufacturing restrictions (accessibility for tools, demolding ability, etc.) mean that delicate and highly structured components can be produced, e.g. with anisotropic, locally-varying or functionally integrative properties and movable components.
- Personalized solutions (customization) can be implemented where products are tailored to user or application-specific requirements (e.g. prostheses, shoes).

The last two points are the key drivers today, contributing to the increasing spread of additive manufacturing as an alternative production technique. The central challenge here is to master the competition regarding cost and quality of established batch production processes such as machining and injection molding, and to significantly increase process efficiency (energy use, waste generation, and robustness). This is particularly the case where there are high demands in terms of surface quality and component failure on the application side, such as in aerospace and mechanical engineering, and also in the case of large volumes of personalized mass-produced products (mass customization, e.g. of glasses or shoes).

Since 2005 development, and since 2009 market activity have been strongly influenced by two trends: the increasing activities of open source communities (in particular the RepRap project), and the Fab@Home concept (desktop printing such as MakerBot). The fascination with additive manufacturing techniques, the desire to participate in production processes, the opportunity to produce replacement parts on demand, and the reintegration of consumer product manufacturing into local economies are all important drivers of this development. Whereas this development prin-