

# THE REALITY OF FUNCTIONALLY GRADED MATERIAL PRODUCTS

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## Abstract

Rapid Manufacturing utilizes the application of different materials in parts by stacking a sequence of layers. Based on the requirements of the part, mixtures of materials, so-called Functionally Graded Materials, can be used to compose the product functionality. This process depends completely on the availability of CAD information of the part geometry. Unfortunately, commercially available CAD-systems do not allow the design of graded material structures. TNO developed a computer tool which enables the user to specify Functionally Graded Materials. The system is based on a new approach to define the material composition at any point in the solid.

## Keywords:

Rapid Manufacturing, Material Property, Functionally Graded Material

## 1 INTRODUCTION

Few new technologies have impacted product development as much as layer manufacturing techniques (LMT). Parts produced by LMT are based on adding material instead of removing, e.g. milling. The procedure is based on a 3D CAD model, which is sliced into thin layers by arithmetical means, which can then be made individually as a stack of cross-sections resulting in the 3-dimensional part, e.g. the stereolithography technique, see Figure 1. There are many different techniques to make the slices. Each technique has its own advantages and limitations.

In combination with 3D CAD it provides the product developer with a very powerful tool to optimize its design, and shortens the time needed to develop the product. New technologies such as concept modelers are able to produce prototypes with acceptable tolerances in a short time.

The highest benefit in all layer manufacturing technologies comes from the reduced time to market. It is followed by fast changes in design and flexibility in technical changes both in design and manufacturing processes. Layer Manufacturing Technologies limit these changes to data and not hardware modifications. Hence, improvement of quality and product maturity resulting from testing and field experience can still be introduced without high cost of changing tools or manufacturing processes [1, 2].

LMT enables the possibility to create physical prototypes automatically without any human intervention during the realization of the part. Expanding the number of materials and improving the material properties used in these layer manufacturing processes gave the opportunity to create better quality prototypes. Slowly the quality of the prototypes is improving and proved to have a functional quality.

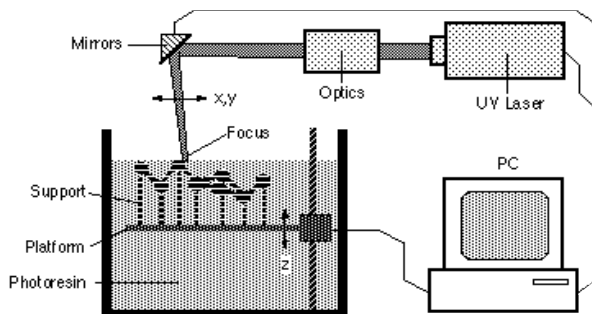


Figure 1 : Schematic design of a stereolithography apparatus.

This is why nowadays, for small series, layer manufacturing technologies are used to produce actual end production parts. Production of end parts with a layer manufacturing technology is known as Rapid Manufacturing (RM).

## 2 RAPID MANUFACTURING

Market potential for Rapid Manufacturing is growing quickly, as is demonstrated by initiatives like the Mobile Part Hospital Program of the U.S. Defense Department [3], and many other examples [1]. Every year, the operational costs of RM are decreased, so the break-even point of a production run of a certain product is stretched. Depending on the geometry and the function of the part, nowadays series sizes of up to 20,000 pieces can commercially be produced efficiently [4].

High potential is seen for parts with complex geometry and less demanding mechanical properties. Rapid Manufacturing techniques excel in mass customized part production. Many of the major manufacturers of hearing aids are in the early stages of using RP to mass customize their products in impressive volumes. Some of these companies produce more than 1,000 in-the-ear hearing aids per day [5]. To fit the patient's ear canal, each product is unique in its shape and size. The process begins with a silicone rubber impression of the ear. The impression is then digitized with an optical scanner and RM used for the rapid production of the hearing aid shell, see Figure 2.

### 2.1 Mono material

The use of Rapid Manufacturing will give designers the opportunity to design products in a different way, no longer limited by the production techniques, like injection molding, deep drawing, etc. This new design freedom involves not only the geometry of the part, but also the material definition of the part can be done in a different way. However, most layer manufacturing technologies are designed

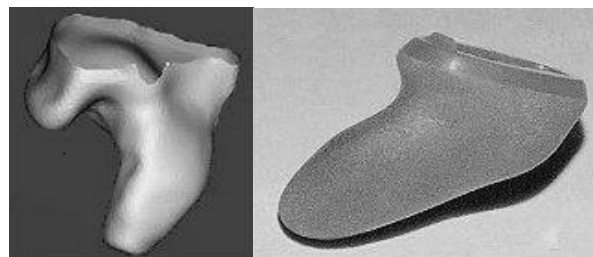


Figure 2 : RM manufacturing steps of a hearing aid.









