3D Printing for Advanced Manufacturing

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The 3D printing technology called UV stereo-lithography (SLA) has been evaluated for the realization of high precision prototypes and for the hybridization of material and fabrication technology. The aim is to form unique components with a high level of complexity and create new opportunities of development. This technology offers a new methodology of product development by enabling a rapid assessment of the feasibility of a design.

Additive manufacturing, also known as 3D printing, is the method of fabricating an object by adding only the material needed, without using a mold or a mask. Several countries are currently massively investigating the development of the different 3D printing techniques, estimated to a total higher than 30. In 2013, President Obama said that "3D printing [...] has the potential to revolutionize the way we make almost everything". It is certainly very optimistic to say that it will replace any fabrication technology so far, but 3D printing is already changing the way we do R&D and prototyping. And it will move forward to the way we develop products. Even if CSEM cannot compete on the development of 3D printing systems with centers receiving funding of several tens of millions dollars, it can still be very efficient in niche markets with high added value components.

For several years, CSEM has been investigating the application of 3D printing to silicon based microfabrication. The objective is not only the hybridization of material but also the combination of fabrication technologies like semiconductor or MEMS microfabrication, glass structuring, electro or electroless plating, surface engineering and 3D printing to obtain components with improved performances or new functionalities.

In an early step, several techniques like UV stereolithography (SLA), fused deposition modelling (FDM) and selective laser sintering (SLS) were evaluated. SLA appearing as the most promising of these technologies, it has been thoroughly investigated in 2016.

The 3D printing system available at CSEM is based on a DLP videoprojector with the UV filter removed in order to achieve the selective cross linking of a UV sensitive resin. A 3D CAD design is sliced in layers of 0.01 to 0.1 mm. Each layer is then projected on the build plate or a substrate to fabricate the components layer by layer and without any mold.

The used material is a photo crosslinkable polymer, which can be mixed with an inorganic material like ceramic (Figure 1). Some of the material parameters are given in the table below.

Polymer	Hardness	Max. operating temperature
High resolution	75 shore D	<100°C
Soft	Shore A 65 Shore D 19	<100°C
Hard	75 shore D	<225°C
Ceramic composite	-	>1000°C if fired

This technology is capable of producing prototype or functional parts, depending of the material used, with an accuracy up to 10-20 µm and a minimum detail size down to 50 µm. It can for example be used to fabricate lattice structures that form lightweight but resistant components. Two examples are presented in Figure 1 and Figure 2 which are respectively a sphere with a 0.4 mm lattice made of a polymer-ceramic composite, and a C letter made of polymer with 0.15 mm tetrahedral lattice. To achieve the realization of hybrid components, a substrate or an object that have received a surface treatment for adhesion promotion, can be loaded on the build plate. A fine alignment system is currently under investigation.

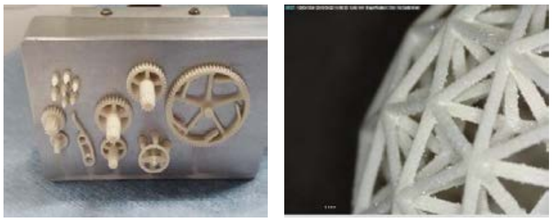

Figure 1: Different ceramic composite mechanical components (left); ceramic composite sphere with a 0.4 mm lattice (right).

Different hybrid components can be achieved with this technique, but a very promising one is a microfluidic device composed of different materials. Here, we are proposing the fabrication of compact and highly integrated fluidic systems made by 3D printing directly on a silicon or glass substrate already processed. In Figure 3, a first demonstrator is shown which consists of a 3D-printed microfluidic system with connectors built on a glass substrate. The channel diameter is 0.25, 0.5, 0.75 or 1 mm.

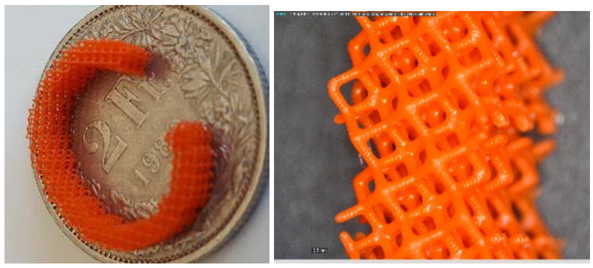

Figure 2: C-shape lattice structure.

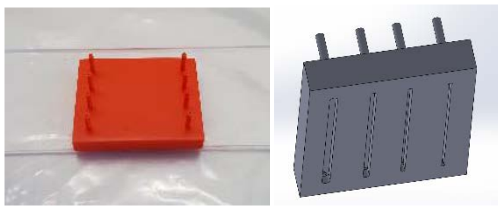

Figure 3: 3D-printed fluidic system on glass substrate (left); CAD design of the 3D-printed part (right).