

Could Nanoimprinting and Additive Manufacturing be an Interesting Combination?

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Motivation

Additive manufacturing (e.g. [1]) is a term that sums up different technologies that all have in common that an object is generated in a layer-by-layer fashion. It has gained tremendous interest due to the interesting possibility to fabricate complex 3D objects directly from CAD data. Each fabricated object can be different from the previous one and it is possible to “3D-print” objects with a geometrical complexity that cannot be achieved by traditional methods.

Nanoimprint Lithography itself can be run in an additive way i.e. multilayer way (e.g. [2][3]), but already just adding one nanoimprinted layer of functional material to an existing surface is an additive process.

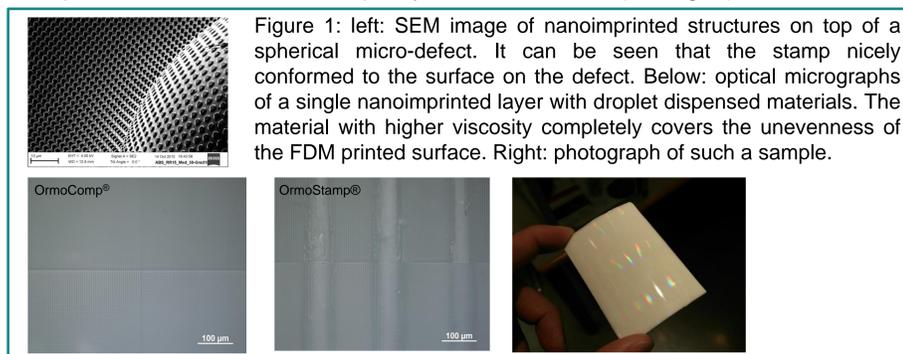
From this point of view, it is interesting to investigate how NIL can support additive manufacturing either by building up 3D layered structures itself or by applying functional additional layers on the surface of a 3D-printed object. This could enable individualized products with integrated functionalities like sensors, displays, solar cells etc.. Here we are interested in the surface modification aspect.

Challenges

There are several challenges that have to be dealt with in this respect:

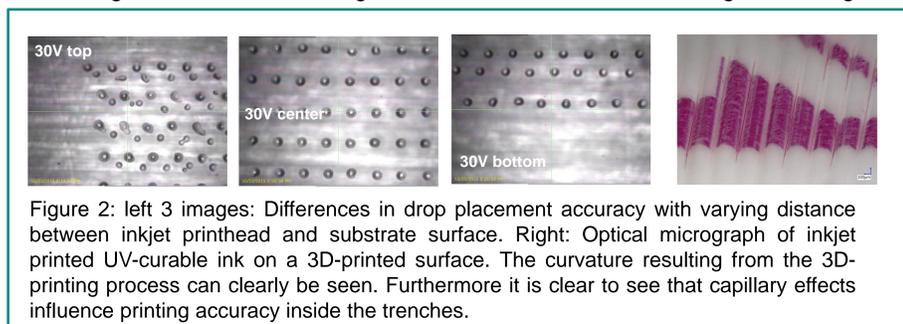
Applying a technology that is used on flat surfaces to curved surfaces

Using flexible stamps NIL can successfully be performed on 3D printed objects [4]. Depending on the viscosity of the materials and the elastic properties of the stamp used, results of different quality can be achieved (see fig. 1).



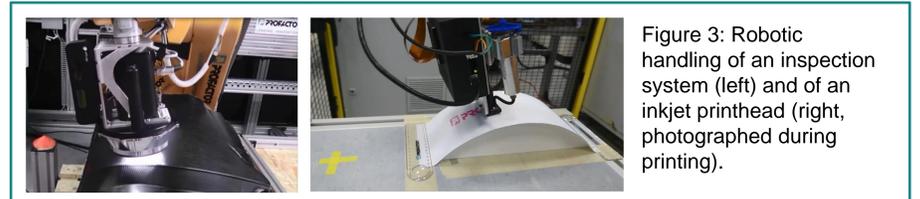
Coping with the rough 3D-printed surface

In addition to the macroscopic curvature of the 3D printed object, also the more microscopic roughness of the 3D printed surface represents a challenge. As shown also in fig. 1 the surface can be smoothed or not depending on the amount and the viscosity of the imprint material. If thinner layers should be deposited on a 3D printed object (on specific places) inkjet printing is an interesting method to do this. Figure 2 shows some of the challenges in doing so.



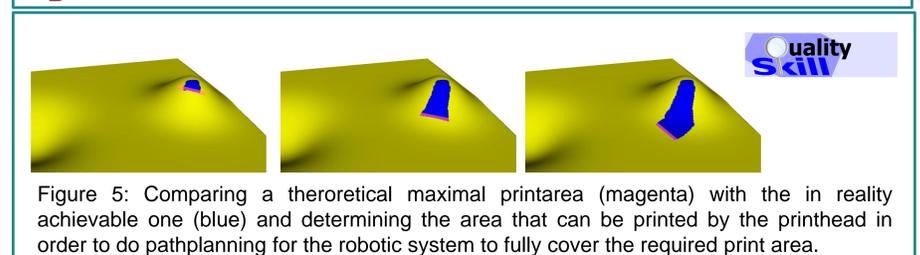
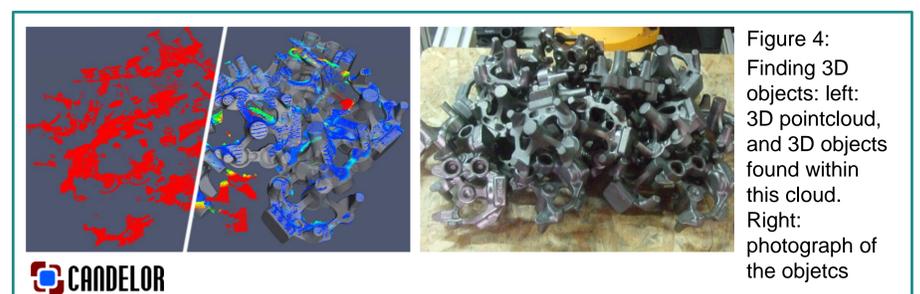
Applying the imprint material on the 3D-printed object

Inkjet printing to apply the imprint material on the right spot is already used in nanoimprint lithography. In our case we want to deposit the material on a 3D printed surface. To do this we are working with a Ricoh Gen 4 printhead mounted on a Stäubli industrial robot. Based on a technology initially developed for surface inspection of carbon fiber parts, we plan to implement inkjet printing on arbitrary 3D printed surfaces (see fig.3)



Finding the right spot on each individual 3D-printed object

But placing the inkjet printhead and subsequently an nanoimprint printhead on the surface makes only sense, if the right position on the surface can be found. To be able to do this, the object has to be found in the first place. Since the CAD data of the object are known (because it was 3D printed in the first place), 3D machine vision can be used to find it in a 3D pointcloud of a typical 3D image sensor. Figure 4 shows an example of what can be achieved [5].



In addition to knowing where to print, it should be possible to understand in advance what area can really be printed. This can be done by investigating the 3D surface and comparing it with the capabilities of the printhead (inkjet or nanoimprint) (see fig.5),

Outlook

Although there are numerous challenges to tackle, using a robotic system to functionalize 3D printed objects by using a combination of NIL and inkjet printing seems possible. This would make numerous individualized functionalized applications possible.

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