# The TopSpot®- Microarrayer: An example for high priced micromachined components creating added value

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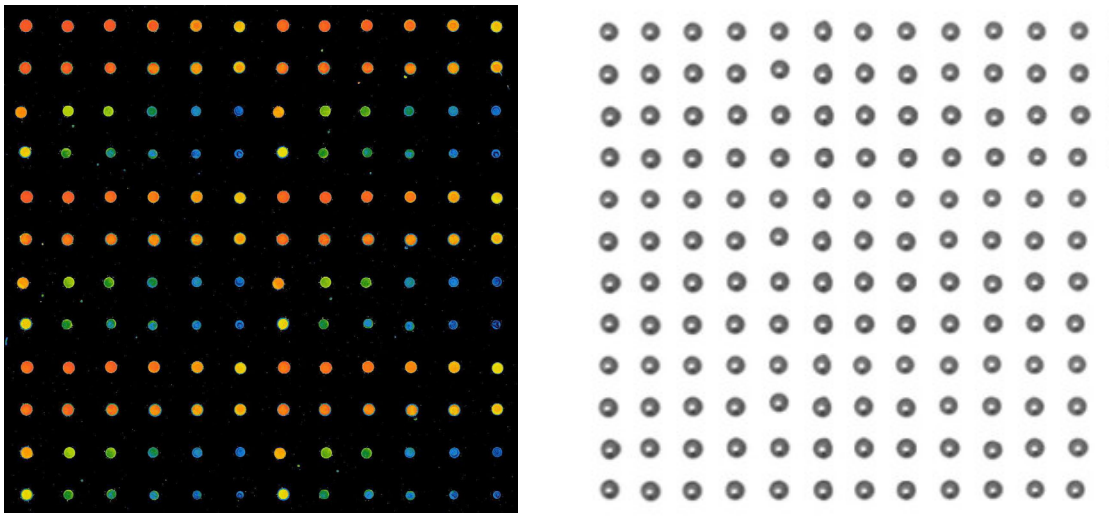
## Abstract

In this paper we present a showcase for effective commercialisation of high priced micromachined silicon components. Such costly components can be marketed successfully if they provided unique functionality and an appropriate added value to the customer. Presenting the TopSpot® microarraying technology it is shown by which strategy the microfluidic key component of the system – the micromachined silicon print head – can be marketed successfully.

## 1.0 Introduction

Microarrays are highly parallel biosensors used in many different applications in the life-sciences, like for example Gemonics, Proteomics, Molecular Diagnostics etc. Their sensor effect is based on a chemical reaction between molecules with a lock and key principle (ssDNA-ssDnA, Antigen-Antibody and similar). When producing a microarray, the different probes are printed and immobilized at a defined pitch on a substrate, typically a glass or a plastic slide. The reaction between the immobilized probes and a complex mixture of molecules is the actual 'measurement'. Captured molecules can be detected after washing off any surplus material by mainly optical or electrical methods [1].



a) b)

Figure 1: a) Fluorescent image of microarray for readout. b) Photograph of droplet array (pitch 500 µm) on a slide directly after printing.

## 2.0 TopSpot® Technology

The TopSpot® technology has been presented a few years ago [2, 3] to be a unique and powerful method for printing low and medium density microarrays. The key component of the TopSpot®-system is the so called print head shown in figure 2. The print head contains wells to accommodate the printing liquids and capillary micro channels to perform a format change from the input format (pitch of wells, typically in the format of a micro titer plate) to the microarray format (final pitch of spots on the substrate, typically 500 µm). The micro droplets – each consisting of a different liquid - are simultaneously ejected from a nozzle array in the middle of the print head. A typical printing cycle with TopSpot® is displayed in figure 3. First the print head is filled with liquids (3 a)) and inserted into a actuation unit (3 b)). The actuation unit mainly consists of a mount to fix the print head, a seal and a piston to enclose a tiny air volume in the so called 'print window' above the nozzle array and piezo actuator with driving electronics to displace the piston. By displacing the piston with the piezo actuator a pressure pulse is created within the 'print window' above the nozzles (3 c)). Readily droplets of about 50-100µm diameter are ejected simultaneously from all nozzles (3 c) –d)). The droplets are thus 'printed' onto the substrate.

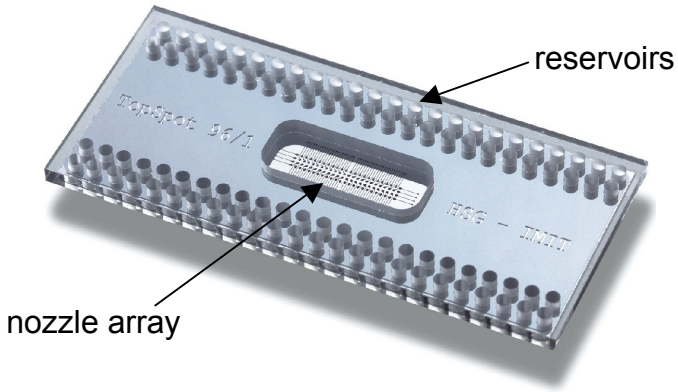



Figure 2: TopSpot® print head with 96 reservoirs made from glass and silicon.

The quality of the print head in terms of dimensional accuracy and surface properties is crucial to the proper printing result. Therefore highly accurate micro machining processes have to be applied for its fabrication. Actually TopSpot print heads are fabricated from glass and silicon material. The nozzles and capillary channels are machined into the bulk silicon material by deep reactive ion etching (DRIE). Then the silicon layer is sandwiched between to glass covers which contain the reservoirs and seal the channels respectively. The required five mask process and the considerable size of the print heads 35 x 20 mm makes them a costly MEMS-product.

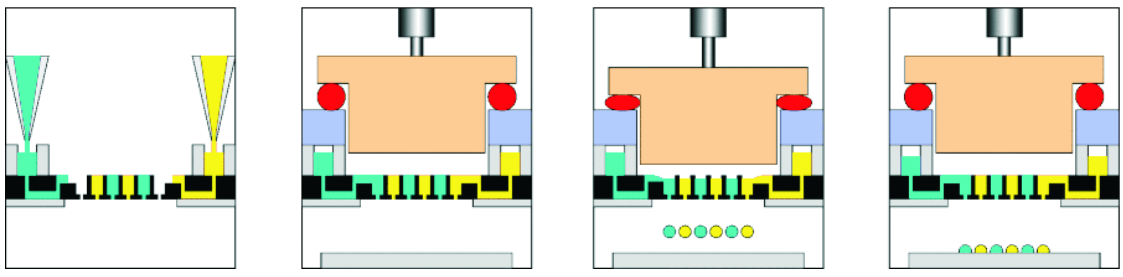
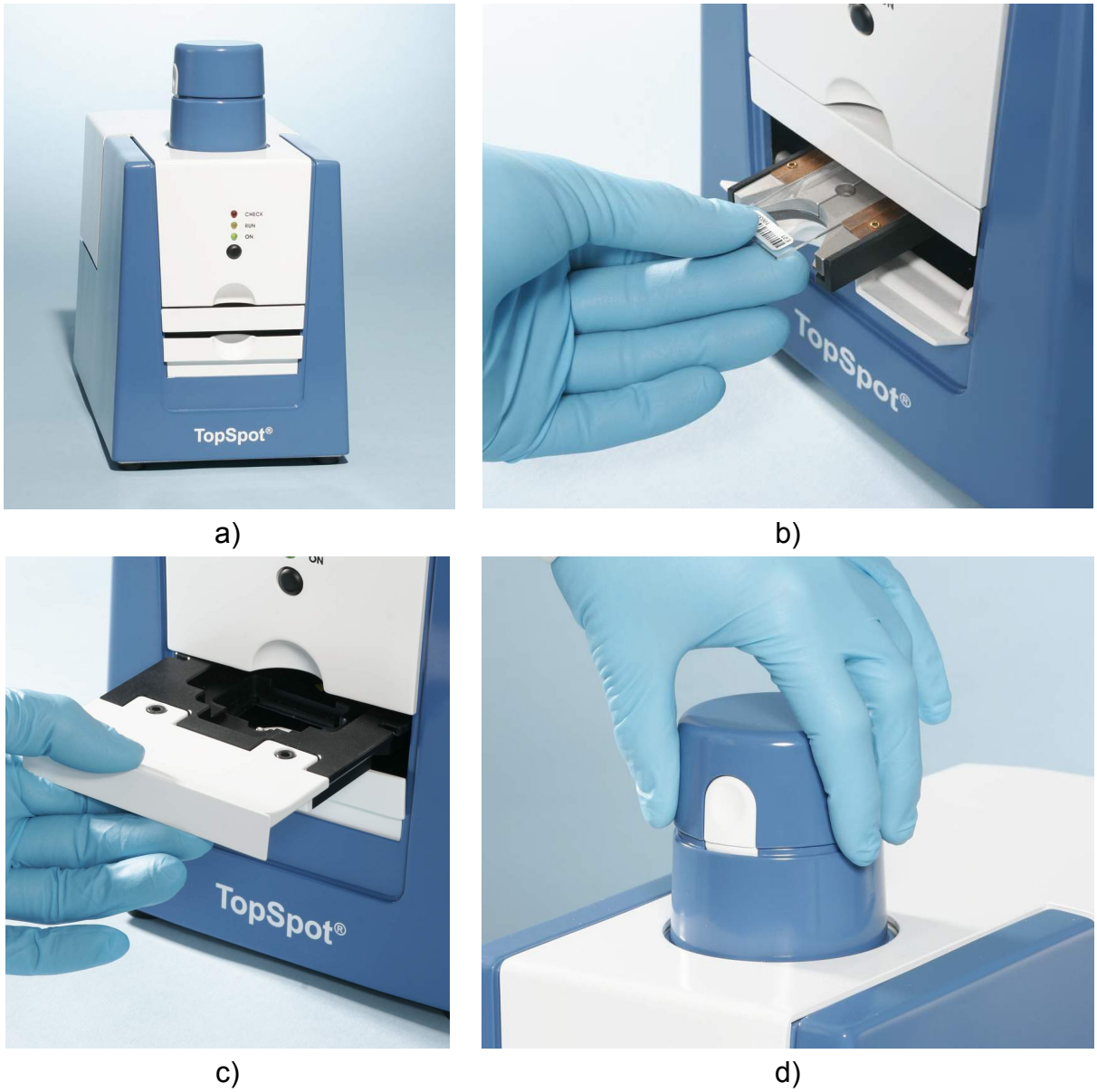



Figure 3: Sketch of the TopSpot® working principle: a) filling b) print head with piston in start position c) piston actuated & droplets ejected d) piston back in start position

## 3.0 Marketing Strategy

The key element for successful marketing of the TopSpot®-technology lies in the excellent performance of the system. Compared to other micro arraying methods like pin-printing or piezo-spotting TopSpot® is faster, provides a better droplet quality and does not require the use of expensive consumables (e.g. pins). The print head which enables this improved performance is comparably high priced with respect to consumables of competing technologies. However, the costs can be justified by the added value provided by excellent performance. Furthermore the silicon print heads are durable and re-usable. Compared to pin-tools they have – in principle – an unlimited life-time, because there is no wear on the silicon material during operation. The whole printing systems like displayed in figure 4 comes with a simple but effective cleaning station enabling the user to easily recondition the silicon print head between successive printing jobs. Thus the superior performance and the reusability of the print head justify the costly micro machining technologies applied for print head production. From this even a competitive advantage arises compared e.g. to pin-tools




a) b)

c) d)

Figure 4: a) TopSpot® E system actually marketed by BioFluidix b) Placing the slide c) Inserting the print head d) Closing the print module

The second very important marketing aspect is, that the whole printing system - print head plus actuation unit - stays at a competitive price compared to existing technologies. In fact the TopSpot® E systems actually provided by Biofluidix is even the least expensive microarray printing system currently on the market. Despite the fact, that the micro machined print head is costly, low overall costs can be achieved due to the simple and robust actuation mechanism. The actuation unit (the so called "print module") driving the print head consists mainly of a mount to fix the print head in position (see figure 4 c)), the driving piston, the piezo actuator and the electronics to control the actuator. The print module can be opened and closed manually by a simple turn lock mechanism to facilitate print head exchange (see figure 4 d)). In addition to the print module the TopSpot® E machine displayed in figure 4 contains an automated slide holder (see figure 4 b)), to safely take up the slide into the machine and to position the slide below the print head. Thus multiple replicates, sub-arrays and arrays can be printed easily, controlled by the included easy to use software.

## 4.0 Summary

The presented TopSpot® showcase proves, that MEMS devices or especially microfluidic devices not necessarily have to be low-priced disposables to survive on the market. Even complicated and large sized microfluidic structures like the TopSpot® print head can be competitive if applied in a proper context. However, to enable this a unique advantage over competing technologies has to be provided to create the additional added value expected by the customer. If a significant advantage over existing technologies can be achieved in terms of performance and costs even costly micro machined components can find there way into products and succeed on the market.

## Literature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