

Magnetic field assisted micro contact printing: a new concept of fully automated and calibrated process

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Abstract

Micro contact printing (μ -CP) ([1] [2]), is a simple and cost-efficient technology well established worldwide. This technology opened new opportunities for various applications such as protein or cellular patterning, surface chemistry, physics, semiconductor ... Interestingly, though its wide application range, there is no standardized or calibrated system permitting to transfer scientific research to industrial applications. Indeed, one of the critical points in μ CP is the control of the force applied on the stamp during the printing step. The technologies developed are always based on a mechanical force (air [3] or hydraulic [4] pressure or mechanical devices [5][6]). The drawback of this choice is that the stamp geometry has to be adapted to the mechanical system.

In this work, we propose a new concept: the magnetic field assisted micro contact printing. For that, we integrated on the upper side of a stamp a quantity of iron powder (25% weight). The stamp became sensitive to a magnetic field. So, changing the magnetic field strength permits to adjust the force applied. Thanks to magnetic force simulations, corroborated by experimental measurements (fig .1), we found that the force can be tuned by the distance between the stamp and the magnet (from 0 to 15 mm) or by the voltage applied on the solenoid (from 0 to 50 V). We used the layer in contact with molecules or nano-objects without iron powder and composed by sylgard 184 in order to be in the same configuration as the previous scientific studies.

In addition to the tuned application force, our design enables to transport the stamp during the process, leading to a fully automated process, ready for industrial applications. Our system, INNOSTAMP40 is thus fully automated and calibrated for better standardization of the technology. This equipment is composed of different modules (fig 2) which correspond to the elementary steps of the μ CP process: loading, inking, alignment, drying, stamping, cleaning and unloading zone. The loading zone can accept up to 4 different stamps with maximum dimensions: 26mm*75mm (glass slide dimensions). There is a temperature regulation on the inking zone (0°C to 50°C) to reduce evaporation. The alignment has a precision of 10 μ m. The drying zone is design to prevent pollution. The calibrated stamping force can be adjusted. We reported the evolution of the printing quality when the force applied increases. The cleaning zone is composed of tanks that can be filled with acid or basic solutions, or solvents. All the steps can be configured thanks to the ergonomic software of INNOSTAMP40.

We demonstrated the genericity of this technique on fig 3. We can use stamp geometry from 1cm² to 19cm² (glass slide format) with normal or macrostamp formats [7] without any mechanical adaptation. These formats permits to ink a stamp in one step with different inks from a well plate (384 or 1536 wells) commonly used in biology laboratories. It shows the adequacy between the INNOSTAMP40 and biological applications (biochip, microarray, lab-on-chip ...) that need multiplexing. Low-cost stamp and macrostamp have been produced. In the latter case, the iron powder could be added at different position into the macrostamp : only on the pad, on the pad and the dot, etc. (fig 4). We have studied the advantages and drawbacks of each configuration.

In conclusion, we have demonstrated that the concept of magnetic stamp permits to propose a new fully automated and calibrated micro contact printing system. This system, INNOSTAMP40, creates a bridge between the lab experiment and its industrial applications.

References

- [1] Y.N. Xia, E. Kim, G.M. Whitesides, J. Electrochem. Soc. **143** (3) (1996) 1070–1079.
 [2] E. Delamarche, H. Schmid, H.A. Biebuyck, B. Michel, Adv. Mater. **9** (1997) 741.
 [3] R. Cracauer, R. Ganske, C. Goh, J. Goh, A. Liederman, R. Loo, P. Tam patent WO2005/061237 (2004)
 [4] K Choonee and R R A Syms J. Micromech. Microeng. **21** (2011) 085013
 [5] S. Hall, R.Nunes, R. Fair, W. Surovic, I. Lovas, R. Emmans patent US2004/0011231 (2002)
 [6] G. Maracas, T. Burgin, T. Mance patent : US5937758 (1997)
 [7] H. Lalo, J-C. Cau, C. Thibault, N. Marsaud, C. Severac, C. Vieu, , Microelectronic Engineering, Volume 86, **Issues 4–6**, (2009) 1428-1430

Figures

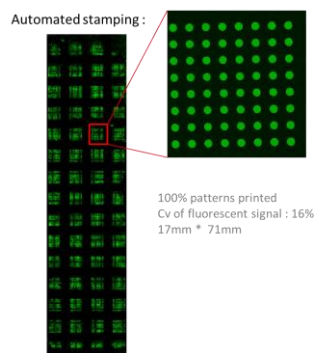


Figure 1. Evolution of the applied force (g) as a function of the distance between the magnetic field source and the magnetic stamp.

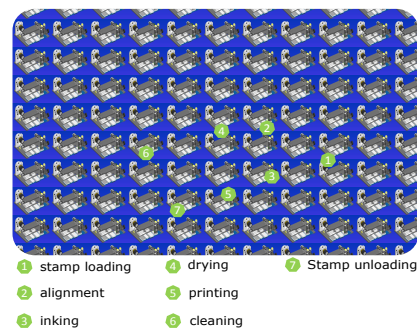


Figure 2. Schematic view of the automate INNOSTAMP40.

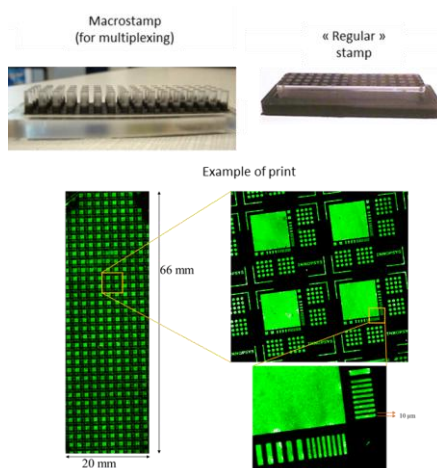


Figure 3. Pictures of “regular” stamp and macrostamp, and an example of print (Cy3 fluorescent dye).

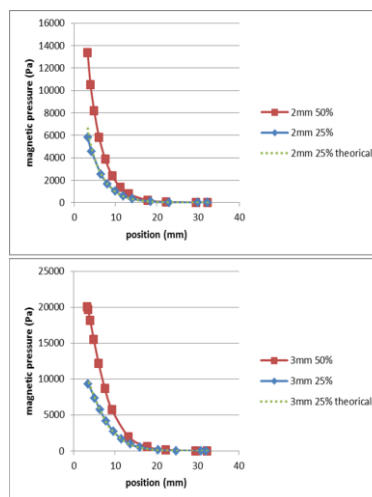


Figure 4. Schematic views and corresponding pictures of different stamp configurations. Green : PDMS, blue : PDMS mixed with iron powder