

# AN EASY-TO-INTEGRATE AND DISPOSABLE MICROPUMP FOR MANUFACTURING MICROFLUIDIC LAB-ON-A-CHIP

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## ABSTRACT

In this work, a new fabrication method for simple, cheap and easy-to-integrate micropump using solid propellant gas generator in tablet form has been characterized. The fabrication method is easy and convenient to use in handling and storage as well as in manufacturing process of microfluidic lab-on-a-chip.

**KEYWORDS:** Micropump, Lab-on-a-chip (LOC), Gas generator, Tablet format, Manufacturing

## INTRODUCTION

Solid propellant gas generator (AIBN, azobis-isobutyronitrile) that is decomposed by heat energy to produce Nitrogen gas has been used as an on-chip micropump to deliver/transfer reagents and/or sample to reaction chamber [1, 2]. Since the solid propellant material is in form of fine powder, a matrix is required to keep the powder on microfluidic lab-on-a-chip, which has specific properties i.e., fast cure at room temperature, low mechanical strength for the gas to easily pass through during dissociation. The current approach for fabricating solid propellant gas generator on chip uses several polymers as a matrix such as poly-dimethylsiloxane (PDMS), liquid silicone, SU-8, or poly-N-vinylpyrrolidone (PNVP), which typically takes 6~8 hours till it dries out completely. In this work, we propose that a new fabrication method of tablet-formed micropump using solid propellant gas generator, which is easy to use and storage for lab-on-a-chip manufacturing process.

## DESIGN AND FABRICATION

Tablets fabricated by compacting dry powder blends are easy and convenient to use in handling and storage in manufacturing process, which have been widely used for pharmaceutical industry since they provide an accurately measured dosage in a convenient portable package [3]. The manufacturing process is divided into three distinct stages: die filling, compaction and ejection as shown in Figure 1. The diameter and shape of a tabletized AIBN micropump are determined by a combination of a punch-die set. The thickness is also determined by the amount of powder material and the position of the punch during compression. Owing to low cost and rapid fabrication as well as easy handling, micropump tablets can be mass manufactured in microfluidic lab-on-a-chip. Figure 2 shows various sizes of the tabletized AIBN's as a micropump.

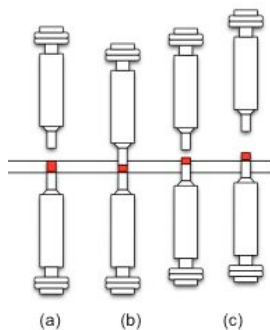


Figure 1: Tablet process: (a) die-filling, (b) compaction and (c) ejection (tablet in red).

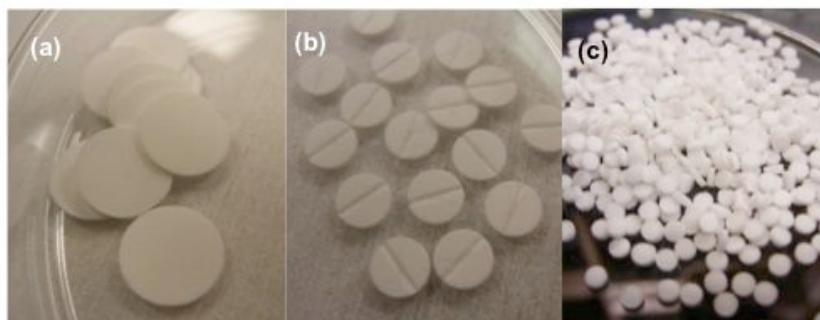


Figure 2: Solid propellant gas generator manufactured from powder form of AIBN using tablet process: "tabletized" AIBN micropumps with (a) diameter 11mm, thickness 0.5mm and flat face, (b) diameter 5mm, thickness 0.5mm and scored face, and (c) diameter 3mm, thickness 0.5mm and flat face.

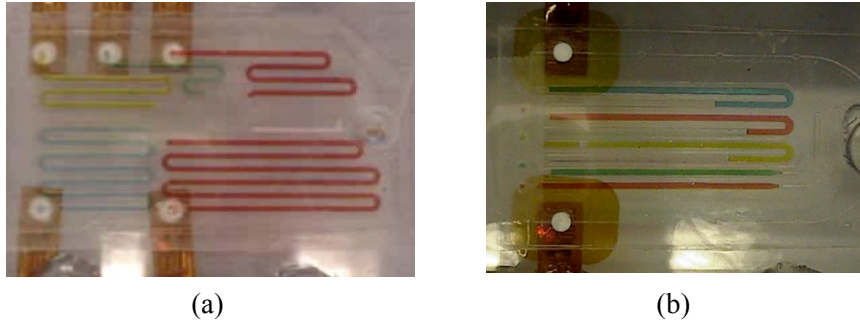


Figure 3: Integrated microfluidic lab-on-a-chip with micropump tablets (white and circular at the end of channels in figure) to deliver reagent in microfluidic channel.

## RESULTS AND DISCUSSION

We characterized the fabricated micropump tablets in a microfluidic lab-on-a-chip as shown in Figure 4. Two 5 mm micropump tablets assembled by a single punch tablet press (YDP-12) were fabricated onto the lab-on-a-chip to transfer washing buffer (70  $\mu$ L), detection antibody (5  $\mu$ L), and whole blood as a sample (10  $\mu$ L) into five reaction chambers serially.

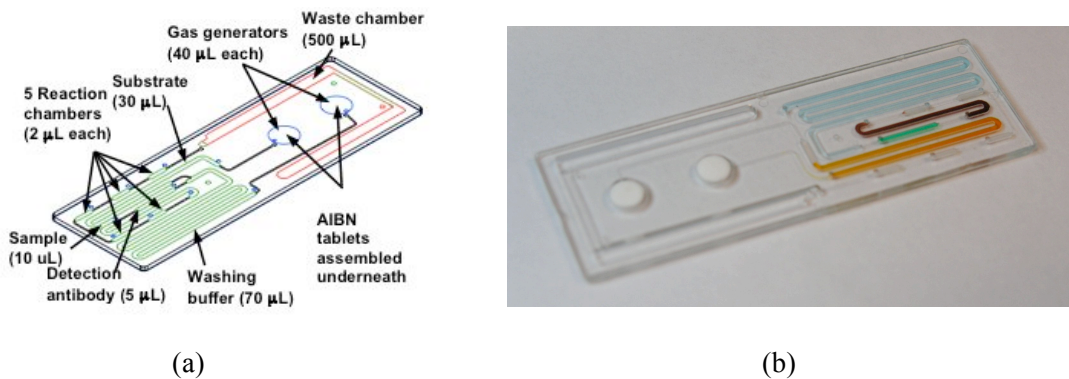


Figure 4: AIBN tablets assembled microfluidic lab-on-a-chip: (a) schematic and (b) fabricated: One of the assembled AIBN delivers series of reagents (washing buffer, detection antibody, sample) into reaction chambers.

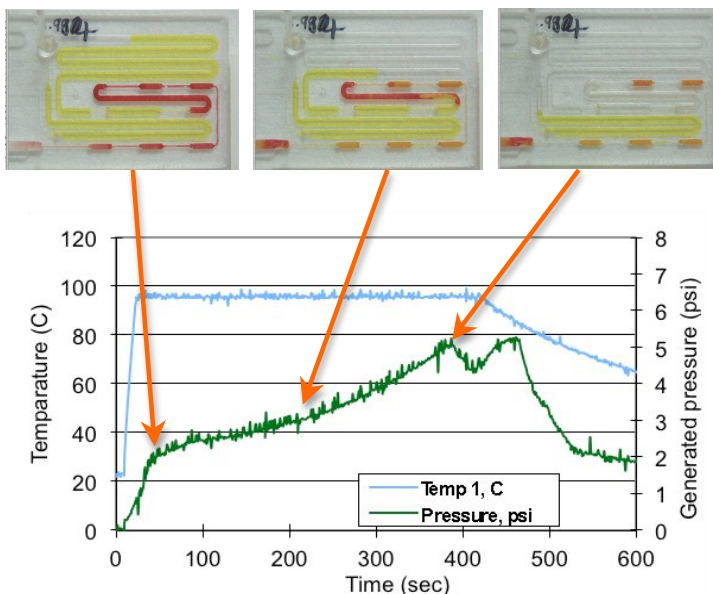


Figure 5: Amount of pressure generated by micropump tablet. Whole blood is passing through five reaction chambers which is packed by capture antibody pre-coated microbeads.

After completing assembly of micropump tablets onto the lab-on-a-chip, it was located on the holder which has two contact heaters aligned with the tablet micropumps. When increasing heater temperature to the decomposition temperature (95 °C), micropump tablet starts to produce Nitrogen gas to build up the pressure which acts as a moving force in microchannel. Since capture antibody pre-coated microbeads were packed in the five reaction chambers to increase sensitivity, whole blood sample exerted to pass through the high resistance of five bead packed reaction chambers.

*Table 1: Flow rate and delivery time*

<i>Reaction Chamber</i>	<i>Empty reaction chamber</i>	<i>Bead packed reaction chamber</i>	<i>Bead packed reaction chamber</i>
Reagent	DI water	Whole blood	Whole blood
Flow rate ( $\mu\text{L}/\text{min}$ )	32.78	18.75	15.38
Delivery time	3m 3s	5m 20s	6m 30s

Approximately 5 psi of maximum pressure was building up as shown in Figure 5. Flow rates and delivery time of total 85  $\mu\text{L}$  if mixture of reagents were measured and compared in Table 1. In terms of flow resistance, the case of whole blood in bead packed chambers showed  $\sim 2$  folds higher than water in empty chambers.

## CONCLUSION

This chemically driven micropump provides many advantages such as low cost, simple structure, and high reliability without moving element in lab-on-a-chip. The proposed fabrication method for AIBN micropump can have the greatest impact as a mass manufacturing of microfluidic lab-on-a-chip.

## REFERENCES

- [1] C.-C. Hong, S. Murugesan, S. Kim, G. Beaucage, J.-W. Choi and C. H. Ahn, "A functional on-chip pressure generator using solid chemical propellant for disposable lab-on-a-chip," *Lab Chip*, 2003, 3(4), 281-6.
- [2] J. Han, S.H. Lee, and C. H. Ahn, "A Disposable On-chip Pressure Actuator using IR-induced Thermolysis for Sample Transport", *The 10th international Conference on MicroTAS 2006*, Tokyo, Japan, Nov. 2006, 588-590.
- [3] A. Abebe, I Akseli, O. Sprockel, N Kottala, and AM. Cuitino, "Review of bilayer tablet technology," *Int. J Pharm.* 2014, 461(1-2), 549-58.

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