

# 3D PRINTED MICROFLUIDIC DEVICES AND RECONFIGURABLE ANALYSIS SYSTEM

Katsuhiro Aritome<sup>1\*</sup>, Wojciech Piotr Bula<sup>1</sup>, Kenji Sakamoto<sup>2</sup>,  
Yuji Murakami<sup>3</sup> and Ryo Miyake<sup>4</sup>

<sup>1</sup>Hiroshima University, JAPAN

<sup>2</sup>Kyushu Institute of Technology, JAPAN

<sup>3</sup>Toyohashi University of Technology, JAPAN

<sup>4</sup>The University of Tokyo, JAPAN

## ABSTRACT

Miniaturization and simplification of chemical analysis systems are very important aspects for the use of environmental monitoring and at-home diagnosis. On the other hand, variety of chemical processes in answer to the requirements of the variety of analytical target has to be performed on that simple system set-up. Therefore, we proposed the quick fabrication method of variety of micro fluidic devices by using 3-D printer assisted with laser carving technology and the concept which allows us to reconfigure the fluid circuit quickly by plugging and changing the fluidic devices (we call it Plug & Flow platform).

**KEYWORDS:** 3D-printer, Laser-cutter, Chemical analyzer

## INTRODUCTION

Miniaturization and simplification of chemical analysis systems are very important aspects for the use of environmental monitoring and at-home diagnosis. On the other hand, variety of chemical processes in answer to the requirements of the variety of analytical target has to be performed on that simple system set-up. Therefore, we proposed the quick fabrication method of variety of micro fluidic devices by using 3-D printer assisted with laser carving technology and the concept which allows us to reconfigure the fluid circuit quickly by plugging and changing the fluidic devices (we call it Plug & Flow platform).

## QUICK FABRICATION OF MICRO-FLUIDIC DEVICES BY USING 3D PRINTER ASSISTED WITH LASER CARVING TECHNOLOGY

Figure 1 shows the top-view of 3D-printer (Stratasys, Objet24) and the working principle. This machine makes the structure by dropping photopolymer onto a tray, curing with UV light and flattening layer by layer. The size of one layer is 28  $\mu\text{m}$ . Figure 2 (a) showed fluidic channels in various widths from 100 $\mu\text{m}$  to 500  $\mu\text{m}$ . The channel of width below 200  $\mu\text{m}$  was not clearly formed. Then, we applied laser carving technology on the polymer devices. Figure 2(b) shows several micro channels made with laser carving machine (UNIVERSAL, VLS3.50, beam diameter is 25  $\mu\text{m}$ ) by changing working speed. The channel of width 100  $\mu\text{m}$  was carved successfully. Though the cross-section of the channel is V-shaped as shown in figure 2(c), it is available as a fluidic channel. Examples of microfluidic devices are shown in Figure 3. It is possible to fabricate those devices within 2-3 hours.

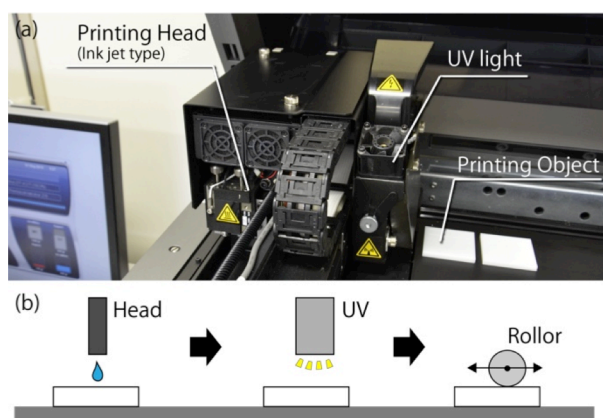


Figure 1: (a) Top view of 3D printer  
(b) working principle (layer by layer)

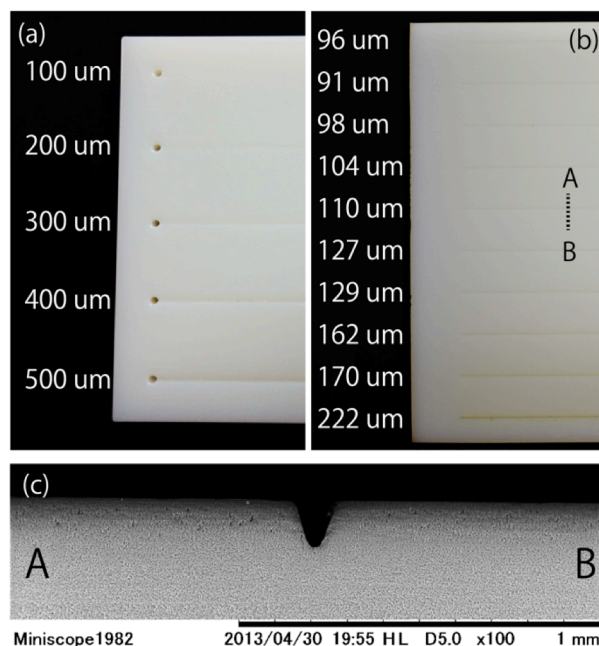


Figure 2: (a) 3D printed micro channels (b) Laser-carved micro channels on 3D printed plate (c) Cross-section of laser-carved micro channel

## CONCEPT OF PLUG & FLOW PLATFORM

Figure 4 shows a prototyped platform [1]. This platform consists of sample inlet & pump driver module, pump module, channel connection module (bottom), fluid control module, channel connection module (upper) and optical module. Channel connection module has 5x5 connection ports matrix of 25 mm pitch. Fluid circuit can be configured quickly for a variety of chemical analysis by plugging and changing microfluidic elements at the connection ports. The size and port pitch of microfluidic element, such as reactor, channel, mixer and the junction are standardized. It reduces design and assembly costs drastically.

## FLUID SYSTEM MECHANISM

Figure 5 shows a fluid flow shipped in the prototyped Plug & Flow platform. The pump consists of disposable syringe which is filled with a reagent. Fluid circuits can be composed by connecting to microfluidic elements at the connection module (upper and bottom). The sample liquid and reagent in each syringe pump are pressurized by backpressure at the sample inlet. Injection timing is controlled by small solenoid valve. Though each flow rate of sample and reagents change depending on the backpressure, it can be estimated by using Kalman filtering method

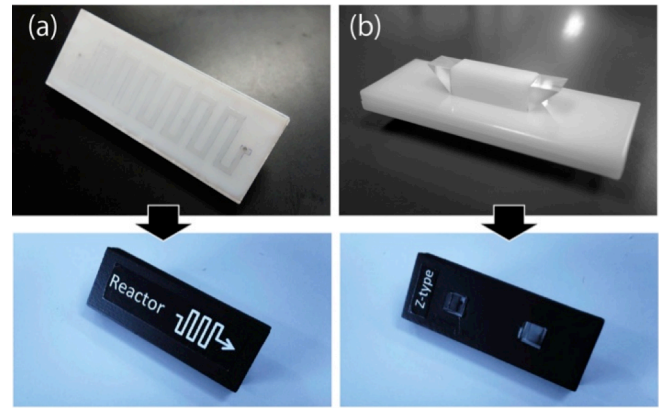


Figure 3: (a) Microfluidic reactor device (b) Optical flow cell for absorption measurement

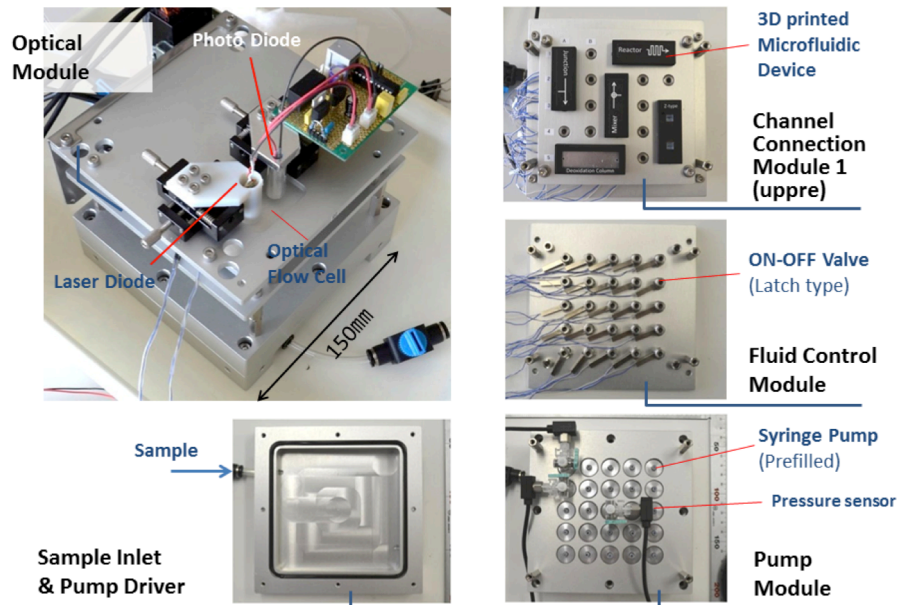


Figure 4: Plug & Flow platform with five module

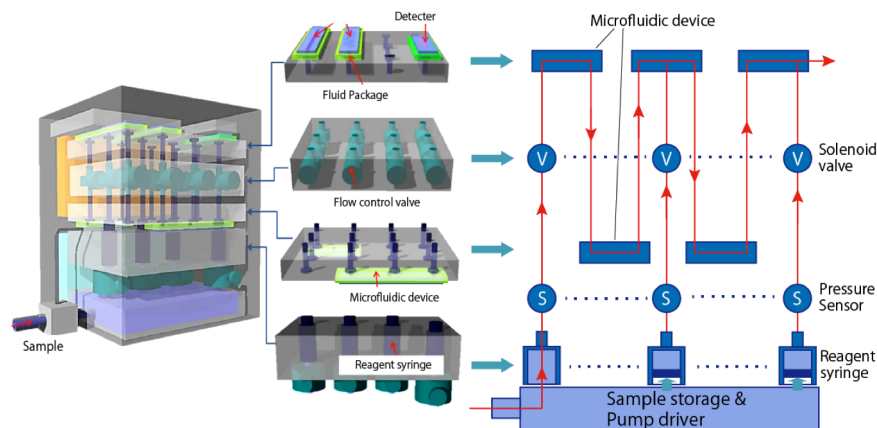


Figure 5: Fluid flow in Plug & Flow platform

with the pressure value of a sensor which is installed in each line between the pump module and the channel connection module (bottom). Figure 6 shows an example of the integration of microfluidic elements. Figure 6(a) is for NaClO and (b) for Nitrate Nitrogen.. The fluid circuits can be constructed quickly corresponding to the flow diagrams shown in the upper side of the figure.

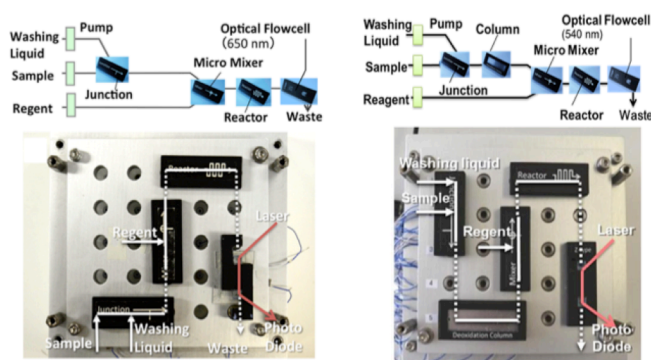


Figure 6: Configuration of (a) NaClO (b) Nitrate Nitrogen analysis

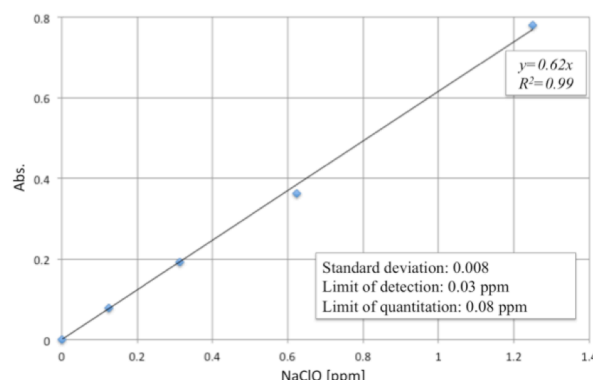


Figure 7: Calibration for NaClO concentration measured by photo diode connecting to LEGO Mindstorms NXT

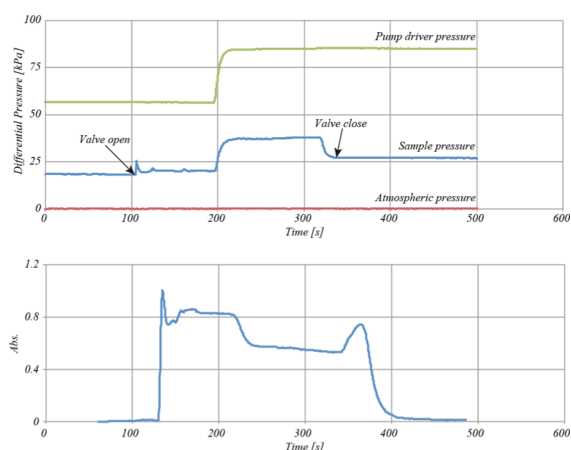


Figure 8: (a) Pressure measurement by valve control (b) Absorption measurement



Figure 9: Outlook of total analysis system with peripherals

## PLUG & FLOW PLATFORM FOR RECONFIGURABLE ANALYSIS SYSTEM

Figure 7 showed calibration result of NaClO (SBT method) on the platform (refer to figure 6 (a)). The light intensity that has passed through the optical flow-cell (refer to figure 3(b)) was measured by photo diode. Standard deviation was 0.008 ppm and lower detection limit was calculated to be 0.03 ppm. This result shows microfluidic devices made by 3D printer stand for reagent chemicals and is available for optical measurement. Figure 8 showed the simultaneously pressure and absorption measurement depending on NaClO concentration. This result showed the monitor could measure continuously. Figure 9 shows outlook of total analysis system integrated with a controller, a wireless communication unit, and a self-energy management system. Total construction time of the system was within a day. Consequently, the unique fabrication method of 3D printed micro-fluidic devices and the concept of plug & flow platform are one of the solution for the quick reconfigurable analysis system.

## ACKNOWLEDGEMENTS

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## REFERENCES

- [1] K. Aritome, W. P. Bula, K. Sakamoto, Y. Murakami and R. Miyake, "Autonomous Compact Water Quality Monitor" Proc. of ISMM 2013, 2013.5.16-2013.5.19, China

## CONTACT

\*R. Miyake, tel: +81-44-223-7031; [trmiyake@mail.ecc.u-tokyo.ac.jp](mailto:trmiyake@mail.ecc.u-tokyo.ac.jp)