DEVELOPMENT OF EMBEDDED METAL LINES IN A PLASTIC ELECTROCHEMICAL MICROFLUIDIC DEVICE BY BLANKET MOLD IMPRINTING

Jung-Ho Seo[1], Jin-Young Kim[1], Hyun-Woo Lim[1], Jin-Goo Park[1], Pei Ling Leow[2], Bhavik Anil Patel[2] and Danny O'Hare[2]

[1]Micro Biochip Center, Hanyang University, Ansan 426-791, Korea

[2]Department of Bioengineering, Imperial College London, England

ABSTRACT

In this paper we introduce a blanket mold imprinting process to prevent complication of the fluid flow and difficulties in producing high pressure seals. In-channel embedded metal lines were also fabricated within the channel allowing electrochemical detections of analytes. Electrochemical microfluidc device has been fabricated on the PET (Polyethylene Terephthalate) substrate by using imprinting method. The resulting devices were applied to microscale chromatographic separation with whole column electrochemical detection. They also were shown to be leak free and stable well in excess of the required operating pressure.

KEYWORDS: Microfluidic device, Electrochemical detection, Embedded metal lines, Blanket mold imprinting

INTRODUCTION

Microfabricated microfluidic devices transport and manipulate minute amounts of fluid through microchannels on the chips fabricated by conventional methods used in microelectronics, such as micromachining, photolithography, injection molding and embossing [1]. The adaptations of electrochemical methods in miniaturized analytical devices offer significant advantages over spectroscopic [2]. In addition, decreasing the size of the working (detecting) electrode improves the electrochemical response which produces higher spatial resolution allowing single cell analysis [3].

This paper proposes a microfabricated microfluidic devices approach for an in-channel electrochemical detection and describes the imprinting method for the fabrication of the embedded metal lines within the channel. Electrochemical cleaning voltammograms are described and the results demonstrate the feasibility of the whole column detection in the microchannel by using electrochemical detection.

EXPERIMENTAL

Polyethylene Terephthalate (PET) plastic substrate was used for electrochemical microfluidic device fabrication using blanket mold imprinting method. Figure 1 shows the process flow of fabrication of microfluidic device. Hot embossing technique was used to imprint the metal lines on PET using blanket mold imprinting. The fabricated plastic substrate with embedded metal lines was sealed with a polyester microchannel using a thermal bonding.

Twelfth International Conference on Miniaturized Systems for Chemistry and Life Sciences
October 12 - 16, 2008, San Diego, California, USA

978-0-9798064-1-4/µTAS2008/$20©2008CBMS

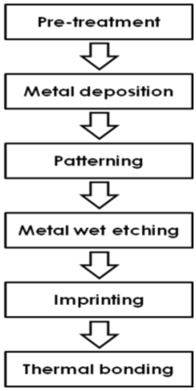


Figure 1. Process flow of fabrication for microfluidic device.

Figure 2 shows the schematic diagram of microfluidic device fabrication. It contained six 50 µm gold wires, where 4 were utilized as working electrodes, with a counter and reference. The channel was 500 µm in diameter and 40 mm in length.

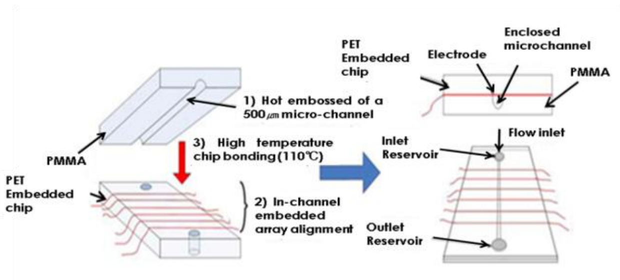
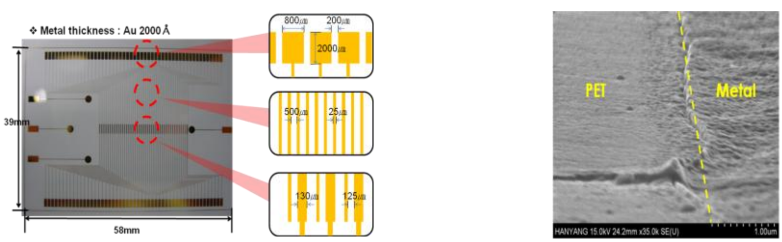


Figure 2. Schematic diagram of fabrication of microfluidic device.

The microfluidic device with in-channel electrodes were characterized using standard redox couples; 1 mM $Fe(CN)_6^{4-}$ and $Ru(NH_3)_6^{3+}$ in 1 M KCl. Hydrodynamic voltammetry and amperometric techniques were used to identify the redox potential and the reproducibility of the in-channel detectors.

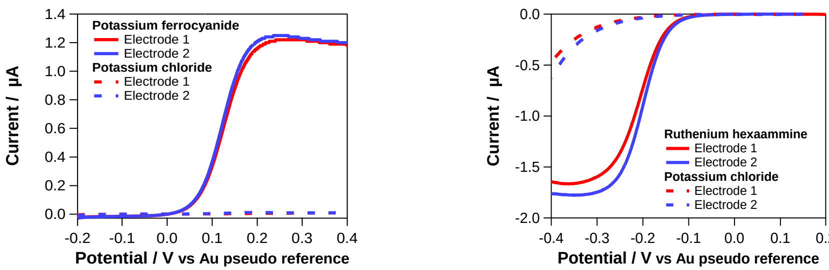


(a) (b)

Figure 3. The result of fabricated microfluidic device; (a) Schematic of the microfluidic chip. (b) SEM of embedded metal line into PET substrate after blanket mold imprinting process.

RESULTS AND DISCUSSION

Figure 3 shows the result of fabricated microfluidic device after blanket mold imprinting. The fabricated metal lines were embedded in the PET substrate by using blanket mold imprinting method with hot embossing equipment. After the hot embossing process, all of the metal lines were successfully fabricated and remained less than 300 Å heights in the PET plastic substrate. Figure 4 shows the cyclic voltammogram of two standard redox couple, ferrocyanide and hexaammineruthenium for electrodes characterization. From the figure, ferrocyanide ($Fe(CN)_6^{4-}$) was oxidized at 300 mV and hexaammineruthenium (III) ($Ru(NH_3)^{3+}$) was reduced at diffusion limited rates at -300 mV.



(a) (b)

Figure 4. Cyclic voltammogram of two different redox couple: (a) Potassium ferrocynide and Potassium chloride, (b) Ruthenium hexaammine and Potassium chloride.

CONCLUSIONS

Imprinting method using blanket mold is a promising technique for PET microfluidic device fabrication. In-channel embedded metal lines were successfully fabricated using hot embossing imprinting method. The fabricated devices were applied to microscale chromatographic separation with whole column electrochemical detection. They also showed leak free and stable operation well in excess of the required operating pressure.

ACKNOWLEDGEMENTS

This work is financially supported by the Ministry of Commerce, Industry and Energy (MOCIE) and the Ministry of Labor (MOLAB) through the fostering project of the Lab of Excellency.

REFERENCES

[1] S.J. Lee and S.Y. Lee, *Micro total analysis system (μ-TAS) in biotechnology*, Appl Microbiol Biotechnol (64), pp. 289–299, (2004).

[2] Fritsch and Z.P. Aguilar, *Advantages of downsizing electrochemical detection for DNA assays*, Analytical and Bioanalytical Chemistry, (387), pp. 159, (2007).

[3] A.M. Bond, *Past, present and future contributions of microelectrodes to analytical studies employing voltammetric detection. A review*, The Analyst, (119), pp. 1R-21R, (1994).