METAL THIN-FILM MICROPATTERNS TRANSFER ON PDMS AND ITS APPLICATION TO CAPILLARY ELECTROPHORESIS ELECTROCHEMICAL DETECTION ON PDMS MICROCHIP

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Abstract

In this paper, metal thin-film micropattern transfer onto PDMS using self-assembled monolayer was used to fabricate a microchip electrophoresis system. Au working electrode and Ag reference electrode were fabricated on the same PDMS substrate for end-channel amperometric detection and the variation of the distance between the electrodes was avoided. Because there is no corrosion of the adhesion layer, the lifetime of the microchip and the reproducibility of the detection were enhanced.

Keywords: capillary electrophoresis, electrochemical detection, metal micropatterns transfer, PDMS microchip

1. Introduction

One of the weak points of poly(dimethylsiloxane) (PDMS) as a substrate material of lab-on-a-chip is that it is very difficult to fabricate metal patterns directly onto it with strong bonding, which is required in the integration of electrodes for electrochemical (EC) detection or applying electric field in the microchannels [1]. The working electrode (WE) and reference electrode (RE) are usually required for EC detection, but it is very difficult to make different metal electrodes on the same substrate using conventional deposition method, such that commercial or homemade reference electrodes are used for EC detection in microchip instead of Ag layer and the distance between WE and RE is difficult to control. Also, the detection system has low reproducibility. In our previous work, we developed a metal thin-film micropattern transfer technique using self-assembled monolayer (SAM) as chemical glue. Using that technique, we have developed a PDMS based capillary electrophoresis (CE) microchip with metal transferred Au WE and Ag RE for end-channel EC detection.

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2. Experimental

The fabrication process of PDMS microchip is the same as that of conventional PDMS fabrication methods except that there is the metal thin-film micropattern transfer procedure which we developed. Before PDMS chip bonding, Au and Ag electrode patterns are transferred to the flat slab of PDMS. The metal thin-film micropattern transfer process is as follows: i) Au and Ag thin-films are deposited onto each glass substrate, ii) electrode micropatterns are fabricated on the metal films by conventional photolithographic process and treated with 3-mercaptopropyltrimethoxysilane (3-MPTMS) in ethanol solution for 3 hrs, and iii) electrode patterns are transferred to PDMS substrate which has been exposed to corona discharge (Figure 1). In the metal electrode transfer process, pre-fabricated Au (200 nm) and Ag (200 nm) electrode patterns are aligned with a microscope and transferred one by one. Therefore, the fluctuations that usually occur in conventional three-electrode systems by using homemade RE are decreased and the reproducibility of the EC detection is increased. Two PDMS plates, one containing microchannel pattern and the other containing transferred metal electrodes, are irreversibly bonded to form the microchip with a microscope to align the position of the electrodes just on the exit of the separation channel (Figure 2). The Au electrode is used as WE, and Ag electrode is used as RE after modification to Ag/AgCl electrode with 5 mM NaCl solution. For a three-electrode system, a Pt wire is used as counter electrode as well as ground electrode for CE. A voltage of 1 kV is applied for CE separation between buffer reservoir and detection reservoir by a high voltage power supply and gated injection is used for sample injection.

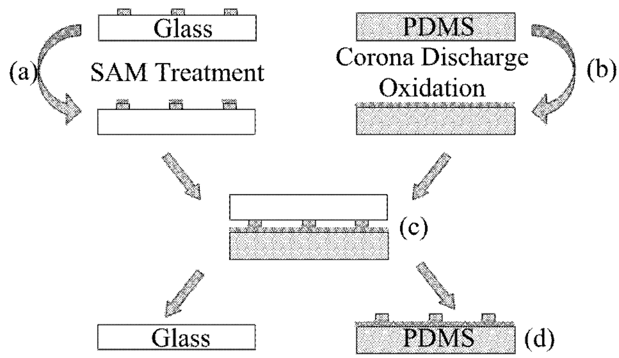


Figure 1. The procedure of metal micropatterns transfer on PDMS substrate.

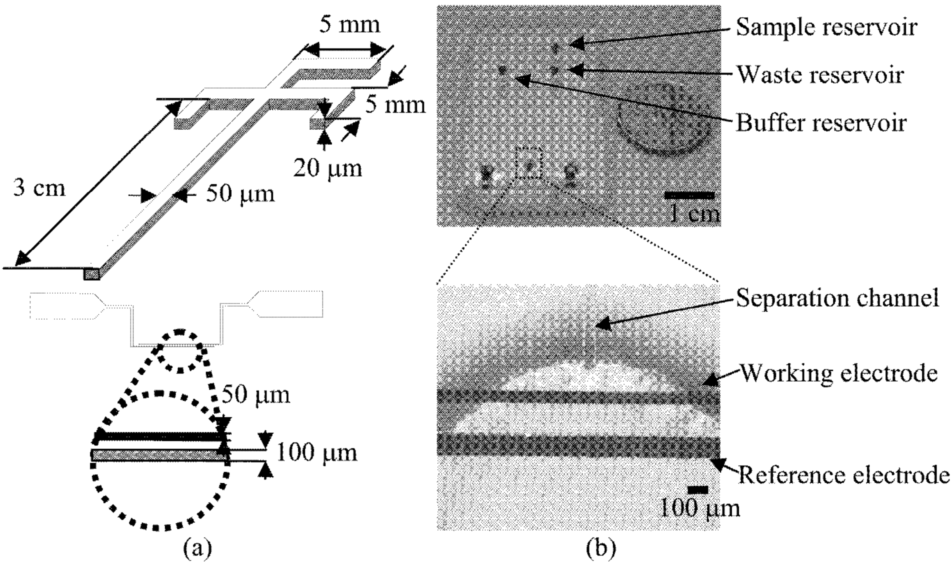
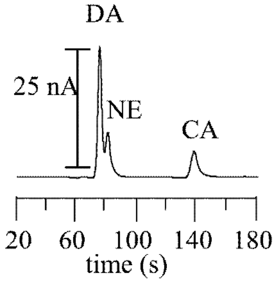


Figure 2. CE-EC microchip on PDMS (a) microchannel and electrode patterns and (b) PDMS microchip and CCD image of electrodes on detection reservoir.

3. Results and discussion

The metal transfer scheme gives many advantages in metal electrode fabrication on PDMS substrate. Metal electrode can be fabricated on the PDMS surface with strong bonding, which is very difficult by conventional methods. It is also possible that different kinds of metal electrodes are fabricated on the same substrate using the method which we developed. In the experiments, a sample mixture of neurotransmitters: catechol (CA), dopamine (DA), and norepinephirine (NE), was separated and detected with end-channel amperometric detection within 3 minutes by the developed microchip CE-EC system. And the result is shown in Figure 3. The position variation of the Pt wire (as a counter electrode) in the detection reservoir makes no difference in the electrochemical detection signal. One of the important features is that there is no Cr layer between metal layer and substrate for strong adhesion. Because the Cr layer is corroded by applied voltage, metal electrodes fabricated on the Cr layer are damaged during the electrochemical detection. The life time of the metal electrodes fabricated with our technique is enhanced greatly. In our experiments, the microchip could be used more than 40 times without damage of electrodes and the sample signal is constant.



Buffer: 20 mM boric acid pH 9.5
5 mM NaCl
Sample: 5 mM DA, NE and CA
Applied voltage = 1 kV (250 V/cm)
E = + 0.7 V vs. Ag/AgCl
Injection: 1 s

Figure 3. Electropherogram of neurotransmitters using CE-EC microchip with metal thin-film micropatterns transfer.

4. Conclusions

We have fabricated PDMS-PDMS microchip with a Au WE and a Ag/AgCl RE via metal thin-film micropatterns transfer technique. With this microchip, neurotransmitters were separated and detected successfully.

References

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