MULTI-POLYMER FABRICATION OF A BIO-FLUIDIC TRANSDERMAL SAMPLING DEVICE

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ABSTRACT

A multi-layer fabrication process using SU8, Polymethylmethacrylate (PMMA) and Teflon were demonstrated for the realization of a robust patch, in particular the Bio-Fluidic Integrable Transdermal (B-FIT) micro-system. A promising dry release process using Teflon was developed. The patch-like device to be worn on the skin had SU8 component layers. In addition, micro-heater elements were integrated onto the PMMA layer. The dermal patch contains micro-channels and fluid encapsulated reservoirs that assist in the transport of glucose molecules from just beneath the dead skin layer to a colorimetric detection membrane situated on top of the multilayer polymeric patch.

INTRODUCTION

Limited accessibility of silicon processing has driven interest in exploring other materials and methods for fabrication of micro-channels. For some applications, a different material that could be patterned and processed at less expense or with a shorter cycle time would be preferable to silicon or glass. A wide variety of polymeric materials meet these criteria, being both inexpensive and easy to process. Many replication techniques exist for forming plastics at the micro-scale level: embossing, casting, injection molding, and imprinting.

New materials and methods for fabricating devices were therefore required and the focus shifted in recent years utilizing polymers for fabrication. Thus, in the present work we explore the use of spin-castable polymer films and develop a new methodology for the fabrication of multilayer polymeric microfluidic devices. A novel integration and multilayer fabrication approach using various polymers like EPON SU8, Polymethylmethacrylate (PMMA) and Teflon has been demonstrated. Metallization within cured SU8 and PMMA layers as well as improvement of metal adhesion has also been addressed.

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EXPERIMENTAL

Overview of Device Fabrication

The paper focuses on the experimental techniques and the processes employed in the fabrication of the base structure of the BFIT (Bio Fluidic Integrable Transdermal) device. Photograph and the top view of a fully functional BFIT on human arm are shown in Figure 1.

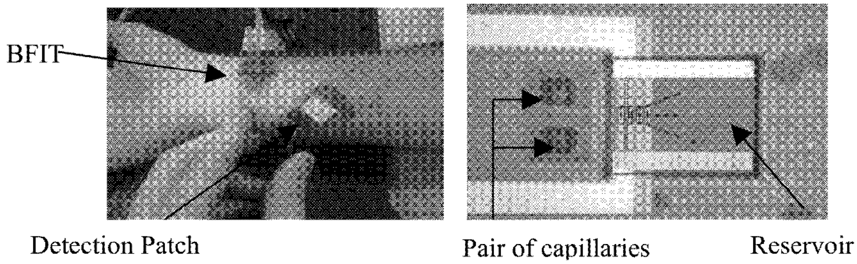


Figure 1: (a) Fully functional B-FIT pictured on human arm, (b) Top view of a B-FIT

The BFIT fabrication process uses SU8 as a principal structural material [1-2] and consists of six steps (Figure 2). The first step, developed for the first time for the B-FIT process, was the deposition of a Teflon release layer on a glass substrate, which allowed the multi-layered SU8 devices to be removed easily from the glass after fabrication. The release layer was formed by spin coating a solution of amorphous fluoropolymers (Teflon) diluted with perfluorinated solvent [3]. A thin layer of SU8 was formed by spin coating and acted as a base layer for the rest of the device and provided adhesion to the Teflon. The second step involved the deposition and patterning of a sacrificial aluminium layer on the cured SU8 surface. Adhesion of aluminium with cured SU8 was improved using a plasma treatment prior to aluminium sputter deposition. Chromium/gold heater metallization was sputtered deposited and patterned on top of the aluminium. The metals were patterned using positive photo resist and wet chemical etching. Fabrication of a uniform membrane layer was the third and a critically important step. The membrane was required to satisfy the conflicting needs of supporting the micro-heater used to thermally ablate the skin and containment of the biological solution in the reservoir, while, at the same time, breaking easily from gas pressure generated by electrolysis inside the reservoir [4]. Further processing on top of the membrane layer consisted of sputter deposition and patterning of the chromium/gold layer used to create the electrodes and contacts for electrolysis inside the reservoir. Before the sputter deposition, a plasma surface treatment was employed to improve the adhesion between the SU8 and the metal layer. The fourth step in the fabrication process consisted of spin coating a thick SU8 layer. This thick layer provided the structural support for the device. Releasing the device from the glass substrate using a razor blade was the fifth step. After the release, the SU8 base layer was dry etched in oxygen plasma down to the initial aluminium layer. The purpose of the dry etch step was to open the bottom of the capillary channel.

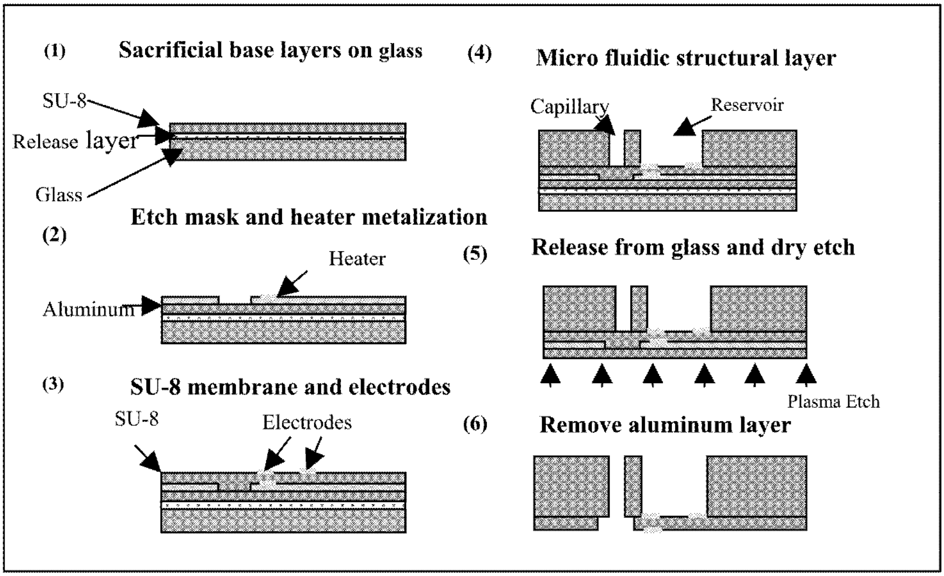


Figure 2: Cross sectional view of a B-FIT process flow

The final part of the fabrication process involved stripping the aluminium layer so that the micro-heater was completely exposed. The device was then plasma treated, so that the porous surface was homogeneous with significantly reduced surface wetting properties. Following this step, the device was ready for filling, sealing [4] and further characterization

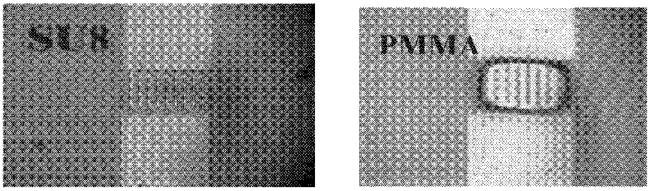
RESULTS AND DISCUSSION

Teflon Release layer

A promising dry release process using Teflon has been developed for the removal of the device from a supporting glass substrate used during fabrication. The details of this process have been described in these proceedings [4].

Membrane Material

Earlier SU8 was used as the potential membrane material in BFIT since it offers the advantage of durability against chemical exposure during device processing, however it was observed that SU8 was not very efficient for membrane rupturing even after applying high voltage (~4-5Volts). Hence a study was undertaken wherein several polymers were investigated as prospective membrane material [5]. PMMA offers the advantage of a lower melting point, in addition it adheres well with other metals and polymers, therefore, it was decided to use PMMA as a membrane material for easier membrane rupturing by the micro-heater elements (Figure 3). Figure 3b shows better PMMA membrane deformation even after applying a low voltage (1.8-2 volts) to the micro-heaters, which is not very evident from Figure 3a.



(a) (b)

Figure 3: (a) Photograph of a partially deformed SU8 membrane on a micro-heater, (b) Photograph of a completely deformed PMMA membrane on a micro-heater.

CONCLUSION

A novel multilayer fabrication for the BFIT devices using epoxy-based negative photo resist SU8 has been developed. SU8 allows for good definition of the reservoir and capillary features by using a photolithographic process. Teflon release technique has been developed and PMMA was demonstrated as the efficient membrane material for BFIT.

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