MICROFLUIDIC GLASS NEEDLE ARRAYS FOR DRUG DOSING DURING NEURAL RECORDING

Elwin Vrouwe, Albert Jan Kelderman and Marko Blom
Micronit Microfluidics, The Netherlands

ABSTRACT

This work reports on the manufacture of in-plane glass needle arrays with needle lengths of up to 7.5 mm. Successful insertion of the needles into a brain tissue model and fluid dispensing has been demonstrated. This paper demonstrates that microfluidic needle arrays with a very sharp tip can be manufactured from glass using only a wafer bonding step and two etching steps. Arrays of two and four needles have been designed specifically for drug dosing during neural signal recording, but can also be applied to other applications requiring microfluidic dosing or sampling.

KEYWORDS: Microneedle, Needle array, Drug delivery, Glass needle

INTRODUCTION

In the Neuroprobes project microneedle arrays are being developed for three dimensional neural signal recording and stimulation [1, 2]. One of the functionalities that are developed is microfluidic needles that will be used for drug delivery. These needles will be used for example to inactivate specific regions of the brain or to administer neuroactive compounds. Hollow microneedles made from silicon have been developed in the past [3], however, the manufacture of these needles requires many steps. This paper demonstrates that microfluidic needle arrays with an improved very sharp tip can be manufactured from glass using only a wafer bonding step and two etching steps. In addition to a significant simplification of the manufacture the substrate material also is much cheaper than silicon since glass sheets are mass-produced in a vast range of thicknesses. The arrays of two and four needles have been designed specifically for drug dosing during neural signal recording in the Neuroprobes project, but can also be applied to other applications requiring microfluidic dosing or sampling. When electrode arrays for neural signal recording are integrated along the needle shafts in the future we also expect to receive less cross-talk using glass as a substrate material instead of silicon.

EXPERIMENTAL

The length of the needles manufactured in this work is adjusted to the animal on which the tests are performed (e.g. rats or monkeys) and are 5 or 7.5 mm. Each needle on the array is equipped with one or two microfluidic channels that are used to dispense fluid into the brain.

Commercially available 100 µm thin borosilicate glass wafers (D263 glass, Schott) are used. First the microfluidic channels are etched 10 deep and 30 wide into the glass using hydrofluoric acid. Subsequently a second unstructured wafer is bonded onto the first wafer and annealed at high temperature. Finally the outlines of the needles are defined by etching completely through the 2-wafer stack from both

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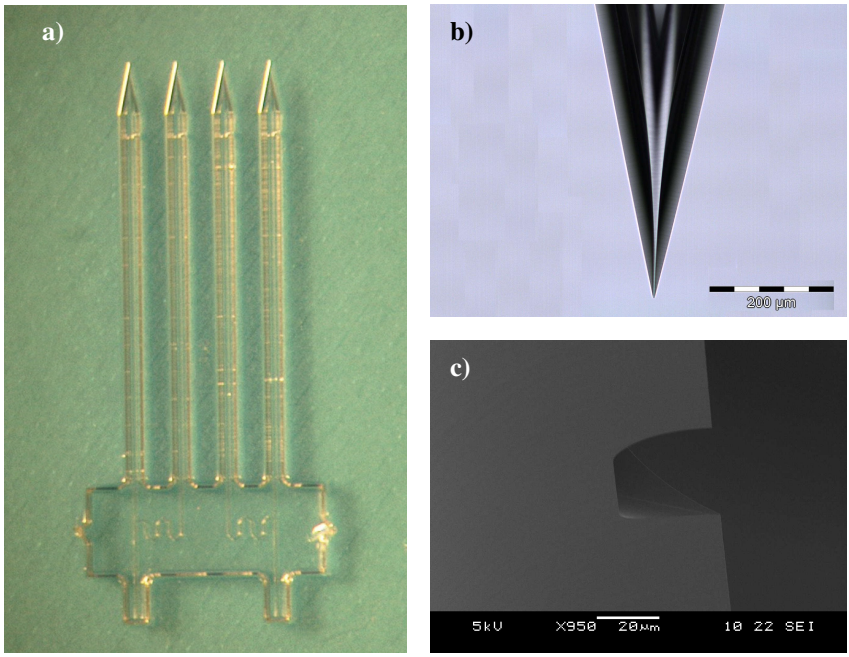

Figure 1. a) Photograph of a glass microneedle array with two fluidic inlets at the bottom and one outlet at the tip of each needle. The needle length is 5mm. b) Image of the glass needle tip and c) SEM picture of the fluidic outlet on the side of a microneedle.

sides of the wafer simultaneously, leaving the individual microneedle arrays attached to the wafer on two hinges at the base of the arrays. The resulting needles are 200 µm thick and 300 µm wide.

RESULTS AND DISCUSSION

Fig. 1a shows an example of a four needle array with two fluid inlets at the base and four outlets at the needle tips. An extremely sharp needle tip is obtained as a result of the isotropic etching behavior of the glass (see Fig. 1b) where DRIE etched silicon needles have a chisel type point. The rigidity of the needles was asserted by successfully inserting arrays manually into an 8% gelatin matrix. The sharp point helps to reduce the force required during insertion into tissue [4]. Dyes (10 mmol/L methylene blue and rhodamine B) were dispensed through the needle outlet shown in Fig. 1c using 250 µL glass syringes connected to fused silica capillaries glued to the inlets of the microfluidic channels (see Fig. 2).

CONCLUSIONS

The glass microneedle arrays fabricated show promise for drug dosing during neural signal recording. In future work electrodes will be integrated onto the glass

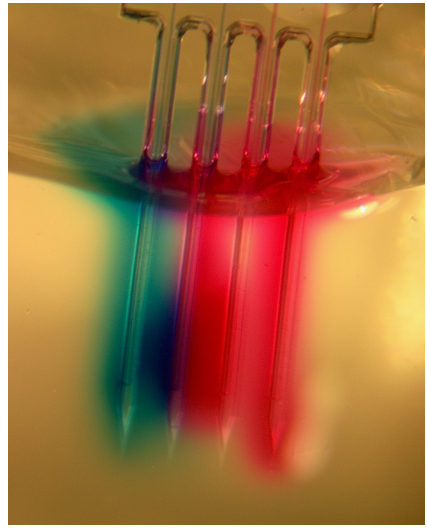

Figure 2. Photograph of a microneedle array inserted into a 8% (w/w) gelatin matrix and dispensing colored solutions through the needles.

needles for simultaneous signal recording and drug dispensing using the same needle arrays. Also multiple microneedle arrays will be mounted into a silicon platform developed in the Neuroprobes project to form 3D arrays of electrodes and microfluidic outlets.

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