Development of a plastic membrane containing micro-hole(s) for a potential bio-sensing application

Krikstolaityte, Vida; Ruzgas, Tautgirdas; Heiskanen, Arto; Canali, Chiara; Arnebrant, Thomas; Emnéus, Jenny

Published in: Procedia Technology

Link to article, DOI: 10.1016/j.protcy.2017.04.108

Publication date: 2017

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit


General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.
Development of a plastic membrane containing micro-hole(s) for a potential bio-sensing application

Vida Krikstolaityt, Tautgirdas Ruzgas, Arto Heiskanen, Chiara Canali, Thomas Arnebrant, Jenny Emnéus

Department of Micro- and Nanotechnology, Technical University of Denmark, Kgs. Lyngby 2800, Denmark
Department of Biomedical Sciences, Faculty of Health and Society, Malmö University, Malmö 205 06, Sweden

Abstract

In this work, a poly (methyl methacrylate) membrane containing micro-holes (MHs) as a prototype of a simple sensing platform of a lab-on-a-chip device has been developed for a potential analysis of clinical fluidic samples. A four probe electrochemical impedance spectroscopy (EIS) setup, with two electrodes placed on each side of the membrane, was adopted for monitoring the MH impedance (Fig. 1a). The setup was used to investigate, if EIS is suitable to sense the trapping of an analyte inside the MHs. Latex micro-beads with a diameter of 10 µm were used to test clogging of the MHs. Additionally, finite element model simulations were performed using Comsol Multiphysics software to theoretically evaluate the sensitivity field of the EIS measurement along the MHs.

© 2017 Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Peer-review under responsibility of the organizing committee of Biosensors 2016

Keywords: poly(methylmethacrylate), lab-on-a-chip, electrochemical impedance spectroscopy, finite element model simulations;

1. Introduction

A particularly important direction in improving the healthcare system is development of portable biomedical devices suitable for rapid detection of infectious diseases at point-of-care (POC) units or at patient’s home. Such POC devices would allow earlier disease diagnosis and increased access to the healthcare in previously under-served environments.

* Corresponding author. Tel.: +45 45 25 68 39.
E-mail address: vkri@nanotech.dtu.dk
populations and home-testing approach in well-developed countries [1]. The design of these devices must be low-cost, miniaturised and enable simple real-time on-site diagnosis. Electrochemical sensing based microfluidic lab-on-a-chip systems enable simple, relatively selective and sensitive analysis of fluidic samples when handling small amounts of fluids and, thus, allowing their miniaturised design which makes them suitable for POC devices.

In this work, a “sensitive hole” based approach was exploited for developing a prototype of a simple sensing platform of a lab-on-a-chip device for a potential analysis of clinical fluidic samples, where a four probe electrochemical impedance spectroscopy (EIS) setup was employed to monitor impedance changes across the micro-hole MH(s) in a non-conductive poly (methyl methacrylate) (PMMA) membrane.

2. Results and discussion

MHs with a diameter ranging between 20 to 300 µm were perforated in 250 and 500 µm thick PMMA membranes by using continuous CO₂ and pulsed fiber laser ablation and mechanical micro-drilling. Both by continuous CO₂ and pulsed fiber laser perforated MHs were characterised as having a conical shape and low reproducibility in the diameter, while mechanically drilled MHs had well defined cylindrical shape and size. Thus, cylindrical mechanically drilled MHs (a diameter of 100 µm) were chosen to clog their interior by amino-functionalised latex beads (a diameter of 10 µm) and evaluate the corresponding impedance changes. For this purpose, the surface of MHs was rendered hydrophilic using air plasma, and the bead trapping inside the MHs was led by capillary forces. The beads within the MHs were cross-linked by using glutaraldehyde vapour to stabilise the bead “net”. The influence of the aspect ratio of MHs on their impedance was evaluated when using PMMA membranes of two different thicknesses, i.e. 250 and 500 µm, respectively, containing a single MH with a diameter of 100 µm. When comparing the ratio of the impedance of modified and unmodified MHs, EIS measurements along MHs showed that the presence of beads in the MH considerably increased the impedance of the MHs in both cases (Fig.1b). Though the higher impedance ratio, i.e. the higher normalized response, was observed for the MHs perforated in 500 µm PMMA than the ones in 250 µm PMMA. Thus, the lower MH aspect ratio enables the higher normalized response of MH-based impedance measurement.

Finite element model (FEM) simulations using Comsol Multiphysics software performed for differently thick (175, 250, and 500 µm) PMMA membranes, when assuming a 100 µm MH diameter, showed that the highest sensitivity of the EIS measurements is obtained in the middle of a MH (Fig. 1c). FEM simulations were performed according to the previously described instructions [2].

Fig. 1 (a) A schematic representation of the EIS measurement setup; (b) EIS spectra of unclogged and clogged MHs in 500 µm PMMA. The inset shows an optical microscope image of a MH clogged by 10 µm micro-beads, (c) EIS measurement sensitivity along a MH: finite element model (FEM) analysis for 500 µm thick PMMA.

Acknowledgements

The work was financially supported by HC Ørsted Postdoc – COFUND programme.

References