Saudi Pharmaceutical Journal (2016) **24**, 1–20

King Saud University

Saudi Pharmaceutical Journal

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REVIEW

Biomedical microelectromechanical systems (BioMEMS): Revolution in drug delivery and analytical techniques

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Received 22 August 2013; accepted 14 December 2013
Available online 23 December 2013

KEYWORDS

Microelectromechanical system;
Drug delivery;
Microfabrication

Abstract Advancement in microelectromechanical system has facilitated the microfabrication of polymeric substrates and the development of the novel class of controlled drug delivery devices. These vehicles have specifically tailored three dimensional physical and chemical features which together, provide the capacity to target cell, stimulate unidirectional controlled release of therapeutics and augment permeation across the barriers. Apart from drug delivery devices microfabrication technology's offer exciting prospects to generate biomimetic gastrointestinal tract models. BioMEMS are capable of analysing biochemical liquid sample like solution of metabolites, macromolecules, proteins, nucleic acid, cells and viruses. This review summarized multidisciplinary application of biomedical microelectromechanical systems in drug delivery and its potential in analytical procedures.

Contents

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Peer review under responsibility of King Saud University.

ELSEVIER Production and hosting by Elsevier

1319-0164
http://dx.doi.org/10.1016/j.jsps.2013.12.003

1. Introduction

Microelectromechanical systems (MEMS) is also called microfabricated devices, lab-on-chip, microsystems, micro-total analysis systems (micro TAS), which existed for more than 30 years, with several applications attaining commercial and/or scientific success. Commercially, high-throughput, low-volume-consumption technologies such as whole genome sequencing projects and drug discovery have created a need for these devices. Scientifically, the ability to design and control experiments at the micrometer scale has attracted the interest of biologists, who have started devising fundamental studies using this technology (Joel et al., 1999).

MEMS techniques were originally developed in the microelectronics industry. Microelectronic process engineering is a discipline that developed due to the rapid growth of the integrated circuit (IC) industry. Traditionally, microelectromechanical systems (MEMS) have been used to produce functional devices on the micron scale, such as sensors, switches, filters, and gears, from silicon, the dominant material used throughout the IC industry. Microelectromechanical system (MEMS) techniques have enabled development of miniaturized diagnostic tools and high throughput screening assays for drug discovery and tissue engineering (Sant et al., 2011). Although in their embryonic, microfabrication technologies are being explored for drug delivery.

The review summarized detail account of how to prepare MEMS device, various strategies of it and application of MEMS in drug delivery and in analytical methods.

2. Strategies for fabricating patterned MEMS

There are four basic processes are used for the fabrication of MEMS. The first is photolithography or soft lithography, which transfers a pattern into a material. The second is thin film growth/deposition, in which thin films (usually on the order of micrometers in thickness) are grown or deposited onto a substrate. Etching, the third kind of process, creates features by selectively removing materials (either thin films or substrate) in defined patterns. The final kind of process is bonding, where two substrates (often structured and with thin films) are bonded together.

Photolithography process depicted in Fig. 1 is used to transfer a pattern envisioned by the designer into a material. A pattern, drawn with a computer assisted design (CAD) program (Fig. 1a), is transferred onto a mask (Fig. 1b). The mask is a glass plate that has on its surface a photo definable opaque material (usually chrome) in the desired pattern and is typically prepared by a mask vendor. If the features and tolerances in the pattern are relatively large (> 20 μm), then one can use a simpler mask-making process (Duffy et al., 1998). After mask making, the pattern transfer begins when the substrate (Fig. 1c) is spin-coated with photoresist (Fig. 1d), a photosensitive organic polymer. The substrate and mask are brought into contact, and UV light is shown through the mask and onto the photoresist (Fig. 1e). Photoresist under the transparent portions of the mask will be exposed, causing it to become soluble in a developing solution. This is known as a positive photoresist (negative photoresist gives the inverse pattern). The wafer and mask are separated, and the exposed photoresist is removed in the developing solution (Fig. 1f). The photoresist can now be used as a protective mask to transfer the pattern into the underlying material via etching. When finished, the photoresist is removed.

Soft lithography is the collective name for a set of lithographic techniques Replica molding (REM), Microcontact printing (μCP), Micromolding in capillaries (MIMIC), Microtransfer molding (μTM), Solvent-assisted micromolding (SAMIM), and Nearfield conformal photolithography using an elastomeric phase shifting masks that has been developed as an alternative to photolithography and a replication