CHEMICAL MODIFICATION OF SUBSTRATES BY PHOTO-ABLATION UNDER DIFFERENT LOCAL ATMOSPHERES AND CHEMICAL ENVIRONMENTS FOR THE FABRICATION OF MICROSTRUCTURES

RELATED APPLICATION

This application is based on U.S. Provisional Patent Application Serial No. 60/256,654 filed Dec. 19, 2000, the complete disclosure of which is expressly incorporated herein by reference.

TECHNICAL FIELD

The present invention relates to the fabrication of microstructures. More particularly, the present invention is directed to a one-step method of forming microstructures in substrates using photo-ablation under a chemical atmosphere that forms the microstructure while altering the chemical functionality of the microstructures.

BACKGROUND ART

A number of competing technologies are currently used for the fabrication of microstructures in polymers including reactive ion etching, plasma etching, x-ray photolithography, chemical etching and template imprinting. However, with each technology there exists an associated disadvantage. In the case of reactive ion and plasma etching, highly specialized equipment, reactive gases, and high vacuums are required. X-ray photolithography (or LIGA) is extremely expensive and requires a synchrotron radiation source, which are in limited number throughout the world.

Currently there are no reports of controlling the chemical functionality of a polymer surface during the fabrication of microstructures. At most, fabrication is completed in one step and functionalization is completed in a subsequent step. In most instances, functionality (or lack thereof) is considered an uncontrollable byproduct of the utilized fabrication process.

DISCLOSURE OF THE INVENTION

According to various features, characteristics and embodiments of the present invention that will become apparent as the description thereof proceeds, the present invention provides a method of forming a microstructure in a substrate, which involves:

exposing a surface portion of the substrate to a light source while providing a chemical atmosphere at the surface portion, so that the light causes ablation of the substrate while the chemical atmosphere effects a change in the chemical functionality of the substrate in the ablated portion thereof.

The present invention further provides a method of fabricating a microfluidic system having fluid flow channels, which involves:

providing a substrate; and

exposing a surface portion of the substrate to a light source while providing a chemical atmosphere at the surface portion, so that the light causes ablation of the substrate and formation of microchannels therein while the chemical atmosphere effects a change in the chemical functionality of the substrate in the ablated portion thereof.

BRIEF DESCRIPTION OF DRAWINGS

The present invention will be described with reference to the attached drawings, which are given as non-limiting examples only, in which:

FIGS. **1***a* and **1***b* are diagrams, which depict the manner in which photo-ablation is conducted under controlled atmospheres.

FIGS. **2***a*–**2***c* are cross-sectional views of channels which are formed by photo-ablation according to the present invention.

FIGS. **3***a*–**3***c* are fluorescent images of channels that depict the effects of different liquids on surface charge.

FIGS. **4***a*–**4***b* are fluorescent images of channels that depict the effects of different on surface charge.

FIG. **5** is a graph that depicts electroosmotic mobility of polycarbonate under different ablation conditions.

BEST MODE FOR CARRYING OUT THE INVENTION

The present invention provides a method for fabricating microchannels, microvials, and other microstructures in different substrates which utilizes photo-ablation techniques. Moreover, the present invention involves controlling the atmosphere and chemical environment local to the site of photo-ablation, in order to alter the chemical functionality as well as to control the charge density on the substrate surface. The ability to functionalize a substrate during the fabrication step allows one to construct devices in which microfluidic flow and chemical specificity may be tailored towards specific applications.

The present invention provides a one step photo-ablation process that is performed under different gas and liquid atmospheres to simultaneously pattern microchannels and functionalize the surface in various polymer substrates. During the course of the present invention it has been discovered that by changing the local atmosphere surrounding the ablation site it is possible to alter the chemical nature and surface charge on polymer surfaces during fabrication. This allows two time consuming steps to be integrated into one rapid step.

Potential commercial applications of the techniques of the present invention include the fabrication of micro-total-analytical systems (μ-TAS) which are also referred to as lab-on-a-chip—(LOC) devices. These systems/devices are used for the analysis of chemical compounds and bio-arrays. For example, because of the ability to fabricate microstructures in channels, it is possible to tailor devices that incorporate multiple features (e.g., posts of packed beds). Additionally, the fabrication techniques of the present invention allow one to produce micro-vials that are content specific. Because the process is not limited to a particular class of materials, it can be used in the fabrication of devices in substrates in use today as well as future composites and hybrid materials.

Photo-ablation occurs when a sufficiently energetic beam of photons of sufficient energy and appropriate wavelength is directed onto a surface and consequently chemical bonds are broken resulting in a thermal expansion and pressure ejection of the material.

According to one example of the present invention, a 248-nm KrF pulsed laser was used to ablate polymer substrates. The work surface on which the polymer substrates were placed was a two-dimensional motion-controlled stage that was part of a laser micromachining system (Potomac Systems LMT-4000). The use of a two-dimensional motion-controlled stage allows the formation of linear and/or non-linear channels without moving the laser beam. Alternatively of course, the laser beam could be moved in any desired pattern. In addition to moving the stage, various