

and 1000 μm and optimally between 1 and 100 μm . The width of microchannel **14** is between 0.05 and 5000 μm and optimally between 1 and 1000 μm .

Using standard microchannel formation techniques known in the art, a silicon template, fabricated by photolithography, can be used to imprint microchannel **14**. Further details on the imprinting process may be made by reference to Xu, J. et al., *Anal. Chem.* 2000, 72, 1930–1933, herein incorporated by reference. Alternatively, hot imprinting can be used to form microchannel **14**. Microchannels can also be formed by other common techniques including but not limited to laser ablation, X-ray lithography, soft lithography, or injection molding.

The microchannel **14** is sealed using a lid **22** (FIG. 1(b)). For clarity, lid **22** is not depicted in FIG. 1(a). In a preferred embodiment, lid **22** comprises a film which seals microchannel **14**.

Polyelectrolyte multilayers or PEMs **28** are disposed on the inner surfaces of the microchannel **14**. In the case of a trapezoidal channel, sidewalls **16**, **18** and bottom surface **20** of microchannel **14** can be coated, as well as the lid made of the same material or a different material. In the case where the lid is not coated, the lid retains the native charge of the polymer substrate. In the case where the substrate is negatively charged, the first PEMs layer is positive. PEMs **28** comprise alternating net positively charge layers such as poly (allylamine hydrochloride), or PAH, layers **30a**, **30b** and negatively charged layers such as poly(styrene sulfonate), or PSS, layers **32a**, **32b**.

PEMs **28** are created by exposing the surfaces of the microchannel **14** to alternating solutions of positively and negatively charged polyelectrolytes. The layers are adsorbed onto the substrate **12** or previous layer by non-covalent interactions resulting in multilayers having multiple electrostatic bonds that are stable and uniform.

Although PEMs **28** are depicted as comprising four PEMs, (i.e., two PAH layers **30a**, **30b** and two PSS layers **32a**, **32b**), PEMs **28** may vary in the number of polyelectrolyte layers. For example, PEMs **28** may comprise as few as a single layer (e.g., either a single PAH layer **30a** or a single PSS layer **32a**). Alternatively, PEMs **28** may comprise 15 or more layers of alternating net positively and net negatively charged layers until a desired number of layers are formed. Preferably, PEMs **28** contain a sufficient number of layers such that selected surfaces of microchannel **14** (i.e., the outermost PEM layer) will have a desired, uniform charge. What should become obvious to one of ordinary skill is that, in this case where the substrate is negative, an odd number of layers results in a positively charged top (i.e., outermost) layer corresponding to a PAH layer **30**, while channels with an even number of layers have a net negatively charged PSS layer **32**. In the case where the substrate is positive, an odd number of layers results in a negatively charged top layer while channels with an even number have a net positively charged layer.

Formation of PEMs **28** is provided by deposition of polyelectrolytic layers using a method that may include first treating the substrate **12** with a 1 M NaOH solution at 55° C. for 15 minutes. This pre-treatment step is not necessary for all materials. Next, the substrate **12** was rinsed with 18M Ω -cm deionized water and dried with nitrogen. A 20 mM PAH solution in a 0.5 M NaCl and having a pH 9, was introduced into the microchannel **14** and completely covered the microchannel surfaces **16**, **18** and **20**. The first PAH solution was allowed to stand for 30 minutes. The PAH solution was first removed from the microchannel **14** by rinsing thoroughly with water and the microchannel **14** was subsequently dried. During the 30 minute period, PAH molecules adsorb onto the surfaces **16**, **18**, and **20** surface, thereby forming the first PAH layer **30a**. Alternatively, this

coating procedure may be performed in an enclosed channel where the lid is simultaneously derivatized.

Next, an aqueous 60 mM PSS solution in 0.5 M NaCl, pH 9, was introduced into the microchannel **14**, completely covering the microchannel **14**. The PSS solution was allowed to stand for 30 minutes allowing PSS molecules to adsorb onto the previously deposited PAH layer **30a** thereby forming the first PSS layer **32a**. The PSS solution was rinsed off with water and the microchannel **14** was dried. Alternating layers of PAH layer **30b** and PSS layer **32b** were deposited by applying the appropriate solution for 5 minutes followed by an exhaustive water rinses in between each solution application.

Although PEMs **28** are depicted as having only four layers, the process of applying alternate layers of PAH and PSS can continue further until a desired number of layers are deposited. In this instance, as a result, microchannels with an odd number of layers will have a positively charged top layers corresponding to a PAH layer **30** while those with an even number of layers will have a negatively charged PSS layer **32** as its outermost layer.

Referring now to FIG. 1(c), in one specific embodiment, a microchannel **114** comprises subchannels **115** and **117**. A lid **122** is disposed over the microchannel **114** and may include four holes **124**, **125**, **126** and **127** which serve as fluid reservoirs for the microchannel **114**. PEMs **128** are applied to the surfaces of subchannels **115**, **117** in a manner similar to the deposition of PEMs **28** described above. The lid **122** may or may not be treated but if untreated, lid **22** retains its native charge. The PEMs **28**, **128** provide a means for controlling the flow direction, rate of flow of a fluid, and the electroosmotic mobility (EOF) in the microchannels **14**, **114**. Further, the PEMs **28**, **128** produces microchannels **14**, **114** with excellent wettability, thereby allowing facile filling of the microchannels **14**, **114**. Also, the deposition of PEMs can be used to improve biocompatibility.

As described above, the EOF of the microchannels **14**, **114** is affected by outermost surfaces of the microchannel **14**, **114**. Further, the flow direction in the microchannel **14**, **114** may be altered depending upon the charge of the outermost surface. When an electric current is applied to opposing ends of a microchannel with a negative top layer, in this case PSS, the flow of a solution such as 10 mM phosphate buffer, pH 7 is from anode to cathode in the microchannel. Conversely, the flow in microchannels with a positively charged top layer, in this case PAH, was reversed and the solution flowed from the cathode to the anode and was designated as a negative flow. What should be apparent to one of ordinary skill is that other polyelectrolytes can be employed other than PAH and PSS, and the direction and magnitude of fluid flow in the microchannel will depend on the pK of the polyelectrolyte and the pH of the solution. It should also be apparent that with a positively charged substrate, the deposition order of the layer is reversed.

TABLE 1

Substrate	EOF Mobility
PETG	$4.3 \pm 0.4 \times 10^{-4}$
PC	$3.0 \pm 0.3 \times 10^{-4}$
PS	$2.5 \pm 0.4 \times 10^{-4}$
PMMA	$1.3 \pm 0.4 \times 10^{-4}$

Table 1 summarizes the EOF mobility (cm²/V·s) of microchannels formed in various substrate plastics with polydimethyl siloxane (PDMS) lids.