50 μm below the bottom of the imprinted channel. The results of cross section B-B **1302**, cross section C-C **1304**, and cross section D-D **1306** are shown in columns. The results for the various angled wells are shown in rows. Results along row **1308** are for wells at a right angle or 90 degrees to the axis of flow. Results along rows **1310**, **1312**, and **1314** are for wells at 60 degrees, 30 degrees, and 15 degrees to the axis of flow. The results indicate that a decreased angle of the well achieves a higher degree of mixing.

The results along row **1308** for right angle wells show that there is no lateral transport across the width of the well. As the angle of the wells is decreased, there is increased lateral transport to the point where the flow may be folded over on top of itself more than once. The folding action is an important mechanism that causes efficient mixing.

FIG. **14**A illustrates a plan view of the flow pattern of an embodiment **1400** of a mixer with quantity 4 wells oriented at 15 degrees off of the axis of flow, and well depths set to 50 μm below the bottom of the imprinted channel. FIG. **14**B illustrates a cross sectional view of the flow pattern of FIG. **14**A, as observed from the cross section E-E. The flow lines **1402** and **1404** illustrate that the fluid may exit the first well **1406** and reenter another well **1408** and thereby may fold during the passage through the mixer **1400**.

FIG. **15** illustrates the results of changes in the electroosmotic (EO) mobility of the surfaces of the wells. Different manufacturing processes may create different EO mobilities on various surfaces of the channels. For example, of the manufacturing processes described for the experiments described elsewhere in this specification, imprinting a channel has been shown to yield a different EO mobility than the laser ablation manufacturing method. Further, other methods such as polyelectrolyte multilayers, surface chemistry modifications, EO mobility suppression coatings, and other methods may be used individually or in combination to selectively change the EO mobility of selective surfaces of the mixer.

The results of FIG. **15** illustrate the effects of increasing the EO mobility of the surfaces of the wells with respect to the EO mobility of the remaining surfaces of the mixer. The results are for a four well mixer with 45 degree wells at a depth of 50 μm below the bottom of the imprinted channel. The column **1502** illustrates the results for section B-B, column **1504** illustrates the results for section C-C, and column **1506** illustrates the results for section D-D, all of which relate the cross sections illustrated in FIG. **11**.

For the purposes of this discussion, a ratio of the EO mobility of the wells divided by the EO mobility of the remainder of the surfaces will be r_{EOM}. The row **1508** illustrates the results when r_{EOM} is 1.24. Row **1510** illustrates the results for r_{EOM} of 2.00 and row **1512** illustrates the results for r_{EOM} of 3.00. Row **1508** is illustrative of the approximate r_{EOM} of the experimental results described in FIGS. **7**, **8**, and **9**. The results indicate that as the r_{EOM} is increased, mixing can be enhanced. Thus, when the effect on EO mobility of the remainder of the surfaces other than the channel remain constant, increasing the effect on EO mobility of the surface of the well increases r_{EOM} and correspondingly enhances the mixing. In other words, the increase of the EO mobility, by different manufacturing processes, selectively applied coatings, or other methods may dramatically increase the performance of a mixer of the present invention.

A use for the present invention is the mixing of plugs of fluid. Applications for such a use may be for lab on chip applications wherein several samples of fluid may be analyzed in succession. It would be desirable for the plugs of fluid to be efficiently mixed, but to minimize the axial dispersion of the plug.

FIG. **16**A illustrates a plug of fluid **1602** introduced into the channel **1604**. The channel **1604** illustrates a case wherein the wells of the present invention are not present and represents a baseline case. The mixed plug **1606** is shown downstream.

FIG. **16**B illustrates an embodiment of the present invention wherein a plug of fluid **1608** is introduced into a channel **1610** in which four wells **1612**, **1614**, **1616**, and **1618** are disposed. The mixed plug **1620** is shown downstream. For FIG. **16**B, r_{EOM} is set to 2.00.

FIG. **17** illustrates the results of a computational analysis of the flow of the embodiments of FIGS. **16**A and **16**B. The curves **1702** and **1704** illustrate the average concentration of the plug as it passes the outlet of the mixing channel over time. Curve **1702** represents the plug of fluid from FIG. **16**A and curve **1704** represents the plug of fluid from FIG. **16**B, with r_{EOM} equal to 2.00.

The cross section **1706** represents the analysis results for the point **1708** and cross section **1710** represents the analysis for the point **1712**. Both cross sections are the approximate high point of the concentration. For cross section **1706**, the plug flow with no wells, the average concentration of the reagent is approximately 28% higher than the cross section **1710**. However, the standard deviation, an approximate measure of the degree of mixing, is approximately 3.6 times higher for cross section **1706** wherein no wells were present. The lower standard deviation of the mixture that passed through the inventive wells indicates that the plug of reagent was very well mixed. Further, from the curve **1712**, the plug of fluid is still intact, although slightly elongated when compared to the reagent that was not passed over the inventive wells.

The present invention is a passive device that greatly enhances the mixing of reagents under electrokinetic flow, and to a lesser degree, under pressure driven flow. The present invention significantly decreases the channel length required for mixing reagents by placing wells in the flow channel at oblique angles to the axis of flow. The wells may be of various depths, however, for a given set of reagents, flowrates, and channel geometries, there may be an optimum depth of a well wherein an increased depth may not increase the mixing effectiveness.

Fabrication and operation of the passive micromixing apparatus of the present invention is simplified over approaches that require splitting the fluid flow into multiple smaller channels and then recombining. By contrast, mixing in accordance with the present invention is the result of transverse flow and fluid folding in a single channel, thereby permitting effective mixing of confluent streams with high flow rates.

Electroosmotic flow is a surface driven mechanism that may be enhanced to change the performance of the present invention. For example, increasing the electroosmotic mobility of selective surfaces, such as of the wells, has been shown to increase the effectiveness of the mixer.

The manufacturing process and equipment used in the experiments referenced in this specification are herein defined.

Reagents and Materials. Laser Grade Rhodamine B was used as supplied by Across Organics (Belgium) and dissolved in 20 mM, pH 9.4 carbonate buffer to a final concentration of 0.11 mM Rhodamine B. The buffer solution was made using deionized water from a Millipore Milli-Q system (Bedford, Mass.), and was filtered before use with a syringe filter (pore size 0.22 μm).

Microchannels were made using polycarbonate sheet (PC; Lexan, GE Co., Mt. Vernon, Ind.). Poly(ethylene terephthalate glycol) (PETG; Vivak, DMS Engineering Plastic Prod-