計畫編號:NSC94-2212-E018-001; 研究期間:2005/08-2006/07

剪切型壓電驅動微泵浦之設計製作與測試

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摘要

本計畫將設計與製作新創之剪切型壓電驅動微泵浦,閥門以無閥式擴流器為設計基礎,致動器將採用 PZT 壓電陶瓷,事先利用數值分析比較各種設計幾何,改進目前已知的相關設計並進行製造與測試,製作一系列尺寸變化之微泵浦,並進行壓電驅動位移與流動特性量測,以瞭解相關幾何參數對泵浦性能的影響,並與 ANSYS 有限元模擬結果作比較以驗證合理性,目的為提供剪切型無閥式微泵浦幾何設計最佳化之參考準則。並且建立新型微泵浦之等效電路及系統轉移函數,以作為未來商品化時微泵浦特性控制之依據。目前有關壓電驅動之微泵浦均為壓電彎曲變形模式(Bend mode),即利用壓電致動器之 d31 變形造成壓電片及與其黏貼之微膜片的彎曲變形,此型有泵浦腔體尺寸受限及組裝難度較高之缺點,本計畫將改以剪切變形模式(Shear mode)壓電致動器,當施加與極化方向垂直之電場時,將使致動器產生 d15 剪切變形,並推擠微膜片上之凸塊進而造成微膜之變形,此型相較於彎曲型有驅動力大、頻率高及容易組裝之優點。

關鍵字: 無閥式微泵浦; 擴流器; 剪切型壓電致動器; 等效電路

The Deesign, Fabrication and Test of a Micropump Actuated by Shear Mode PZT Actuator

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Abstract

A novel actuating design that uses the shear deformation of a lead zirconate titanate (PZT) actuator to deflect a diaphragm is proposed and applied to the microfluidic system. A silicon chip is micromachined with the feature of a bulge on the diaphragm by an inductive-coupled-plasma deep-reactive-ion etcher (ICP-DRIE). The shear mode actuator glued on the chip surface pushes the bulge and thus deflects the diaphragm. The analytical exact solutions for the deflection and volume displacement of the diaphragm without fluid load are derived by the analysis of the free-body model. The results are compared with the ANSYS numerical solutions and verified by experiments, which reveals acceptable agreement.The experiment employs a two-dimensional laser scanning vibrometer to measure the diaphragm deflection. The application of this design is realized in a diffuser micropump that further functions as a microdroplet ejector with the introduction of a nozzle plate. The ejected droplets of the microejector are observed by a visualization system.

Key words: Shear mode;PZT actuator;Microfluidic;diaphragm deflection;
Exact solution;Numerical solution