570c A Touch Mode Capacitance Type Injector Valve for a Microscale Gas Chromatography System

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Gas chromatographs have been highly developed for chemical analysis of various low concentration constituents in gases. Recently, microscale gas chromatography (micro-GC) systems are actively being developed using MEMS technology to create portable, low-power systems. These micro-GCs typically consist of a preconcentrator, an injector valve, a microcolumn, and a detector integrated into one device. The injector valve is a key component in the micro-GC system since the injector valve determines the sample injection time from the preconcentrator into the column, which in turns affects the gain of the system. Hence, many different types MEMS valves are being considered as a candidate injector valve for micro-GC's. Piezoelectric and electrostatic actuator valves have been mostly used in gas analysis systems[1,2,3]. Electrostatic valve can potentially offer a fast response time and low-power performance. A key parameter for the valve is the injection pressure that the valve can handle. The higher the injection pressure the valve can handle, the higher the velocity of the gas can be achieved through the separation column, cutting down the analysis time. For a 1 m column with a 100 micron diameter, injection pressures greater than 2 atms are desired to achieve a 4 s separation time. However, conventional electrostatic valve actuators operating under reasonable applied voltages (< 100 V) have difficulty holding off and closing against these relatively high pressure with a fast actuation time. In this paper, we present a touch mode capacitance type injector valve that was developed in order to provide a high electrostatic actuation force with a fast response time by using an electrostatic zipping mechanism[4]. The valve is composed of two pairs of zipping electrodes that share one conducting membrane between them; the first one consists of an upper electrode and the conducting membrane that closes the membrane valve onto the upper electrode; the second one consists of a lower electrode and the conducting membrane that opens the valve faster by pulling the membrane off the upper electrode onto the lower electrode. In order to increase performance of the injector valve, pneumatic actuation is also added to balance the pressure through pneumatic ports on both side of the membrane to decrease the net pressure across the membrane to increase both the pressure the valve can handle and speed of opening and closing. The valve has been fabricated by using the illustrated fabrication steps. The valve performance is characterized by the hold-off pressure, opening/closing response time, and forward/backward leakage flow rate with respect to the applied voltage, respectively. Experimental comparisons of the performances are presented between single touch mode actuation, single pneumatic actuation, and touch mode plus pneumatic actuation. References 1. Shuichi Shoji, Shigeru N. Gawa, and Masayoshi Esashi, "Micropump and Sample-injector for Integrated Chemical Analyzing Systems," Sensors and Actuators, Vol. A21, pp.189- 192, 1990. 2. Kazuo Sato and Mitsuhiro Shikida, "An electrostatically actuated gas valve with an S-shaped film element", J. Micromech. Microeng. Vol. 4, pp. 205-209, 1994. 3. Mike L. Philpott, David J. Beebe, Anthony Fischer, Bruce Flachsbart, Mike Marshall, Norman R. Miller, John C. Selby, Mark A. Shannon, and Yan Wu , "Switchable electrostatic micro-valves with high hold-off pressure, HitonHead, 2000. .4. R. Legtenberg, J. Gilbert, S. D. Senturia, M. Elwenspoek, "Electrostatic curved electrode actuators," Journal of Microelectromechanical Systems, Vol. 6, No. 3, pp.257 - 265, Sep. 1997,.