計畫編號:NSC96-2221-E018-012; 研究期間:2007/08-2008/07

以直流脈衝濺鍍法製備最佳化 PZT 壓電複合膜於微液滴噴孔元件之應用

林義成

摘要

本計畫之目的在利用直流脈衝磁控濺鍍法（PMS, Pulse Magnetron sputter）沈積 PZT 壓電薄膜於矽基底電極基板上，先以田口實驗計畫法（Taguchi Methods）作最佳製程參數探討，並在矽基材上製作由氧化矽、氮化矽兩層低應力薄膜，將所製備之最佳化壓電複合膜結合 ICP-RIE 矽基深蝕刻製程所製作之微流體泵樸之流道與腔體，完成以 PZT 壓電薄膜構成壓電複合微膜之微液滴噴射致動結構。第一年中壓電薄膜的作法，為了後續元件高精度的要求，我們選擇濺鍍法並搭配黃光製程，易於達成陣列化、微小化的精密圖形定義。相較於目前常用的射頻濺鍍法所使用的陶瓷材料靶材、或多靶濺射法，脈衝直流濺鍍法需搭配金屬或合金之具導電性靶材，故本製程改用單一靶材含 Pb/Zr/Ti 之金屬靶，並同時考慮鉛過量之組成比例，以 XRD 半高寬、沈積速率、表面粗糙度作為田口法回應之 PZT 薄膜品質指標，以 L18（21×37）直交表對七項直流脈衝濺鍍參數作最佳化。第二年主要將第一年製作最佳化 PZT 壓電複合膜，製程微液滴噴射致動結構以便

進行 PZT 薄膜應用於微致動器的特性的量測。製程規劃預計將元件分為正反兩面製作，正面製作微流體輸送結構，背面製作 PZT 壓電複合膜微液滴噴射致動結構,並正反面對準貼合後以量測微液滴之噴射狀態。

關鍵字：脈衝磁控濺鍍；PZT 薄膜；脈衝頻率；

能率循環；沈積率；結晶性

Fabrications and Optimization of PZT Thin Film by DC Pulse Magnetron Sputtering and Applications to Micro Droplet Device

林義成

Abstract

In this study we report on the influences of processes parameter for depositing PZT (Lead zirconate titanate) thin film on the silicon based Ti/Pt bottom electrode prepared by PMS(Pulse Magnetron Sputter) using single metallic target with a post deposition rapid thermal annealing. The process parameters of pulse frequency, duty cycle, O2/Ar flow rate ratio, and post annealing time and temperatures has been discussed. The crystalline of film is analyzed by X-ray diffractiometer and the morphology, surface structures and deposition rates of films is analyzed with SEM.The experiments exhibited that the perovskite structure of PZT thin film can be obtained with post annealing treatment at 650℃ for 40s by PMS process at 100℃. The X-ray diffraction intensity of perovskite structure decreases with annealing time but increases with annealing temperature until 750℃. About PMS parameters, the lower pulse frequency, say 10kHz, enhance the deposition rate and X-ray diffraction intensity of perovskite PZT structure. Also, adjusting duty cycle to 80~85% and lower O2/Ar flow rate ratio have enhancement on the deposition and X-ray intensity. The enhancement of perovskite PZT structure by increasing the film thickness is confirmed by SEM and XRD. The perovskite single phase of PZT thin film can be obtained with pulse frequency under 33kHz, or film thickness over 400nm, or O2/Ar flow ratio under 1/10. The deposition rate reach 9.4nm/min at 60W input power. However, the film cracks and lift-off caused by stress appearing as film thickness larger than 550nm, and hillock phenomenon of Ti/Pt(50nm/150nm) bottom electrode both cause the capacitor devices PZT thin film electrically short.

Key words: Pulse magnetron sputter;PZT thin film;Pulse frequency;
Duty cycle Deposition rate;Crystalline