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• 英文關鍵字	Dental implant; Stability; osseointegration; Sol-Gel method; PZT piezoelectric thin film; microsensor		
• 中文摘要	本研究以製造一微型非破壞式可植入型之牙科植體的感測元件，期能進一步與牙科植體組裝成感測裝置，以連續監測牙科植體之初期穩固度及後期骨整合程度。研究中利用高密度電漿化學氣相系統(HDP-CVD)沉積碳化矽(SiC)薄膜於 P 型(100)矽晶圓上，接著以溶凝膠(Sol-Gel)法製備 PZT 壓電薄膜，並以積體電路製程旋轉塗佈的方法將 PZT 壓電薄膜旋轉塗於 SiC 薄膜上。以常壓退火及快速退火方式對 PZT 壓電薄膜進行退火致使 PZT 壓電薄膜具壓電特性，再以微影製程(Lithography)及舉離法(lift-off)製作交叉指狀電極，完成的元件分別以儀器進行薄膜及元件特性分析探討。在壓電微型感測器電性探討及評估上，則是以電阻變化及漏電流測試爲主。經研究結果顯示：SiC 薄膜經一小時氮氣退火後以 AFM 觀察發現表面有明顯結晶且存在有特定的優選方向(Preferred-orientation)。GIXRD 顯示經退火後 SiC 薄膜具(110)優選方向。剛沉積的 SiC 薄膜於微刻痕測試儀進行微硬度測試，其微硬度值約爲 50 GPa。經薄膜應力量測儀測得 SiC 薄膜的應力值爲壓應力(Compressive stress)，且應力值隨厚度的增加而增加。經由 ESCA 進行鍵結分析得知，未經退火處理及退火處理後的 SiC 薄膜之鍵結能量並無任何化學鍵結偏移產生，顯示未經退火處理及退火處理後的 SiC 矽薄膜並無因退火處理使得 SiC 薄膜與氮原子產生鍵結。此結果與 SiC 薄膜經微刻痕測試儀所測得的微硬度值結果是相符的。而爲瞭解 PZT 壓電薄膜之機電耦合特性，則進行 PZT 壓電薄膜相對的疊層結構分析，再分別進行各項分析。以物理氣相沉積(PVD)的鉭膜於二氧化矽與 PZT 壓電材料作爲中間層，經 SEM 觀察得知，鉭膜與二氧化矽及 PZT 壓電材料具有優越的附著能力。以 PVD 鍍著的鉭薄膜經 TEM 觀察得知，鉭薄膜爲多晶相且爲具低電阻率的 α(bcc)體心立方結構。經四點探針測得鉭薄膜電阻值爲約 170 μΩ-cm。溶凝膠法製備 PZT 壓電薄膜經旋轉塗佈再以退火方式進行後處理，以 X-光的繞射分析發現以快速退火後的壓電薄膜具有 PZT 相，且在 PZT 壓電薄膜的蝕刻製程中發現，在純 Cl2 氣體中有最佳的蝕刻效率且具平整的蝕刻壁。而經 TEM 觀察顯示，以 PVD 方式鍍著的銅電極與壓電材料薄膜及鉭薄膜界面彼此並無擴散現象，由此得知鉭薄膜能有效阻擋銅薄膜經 400°C 的回流製程中與壓電材料薄膜中鈦金屬與銅的交互擴散。壓電微型感測器經極化量-電場曲線的量測得知其 Pr 值在 11.9-18.78 μC/cm2，		

	由此得知壓電薄膜製成的感測元件具機電耦合效應。
• 英文摘要	In this study, we designed and also implemented: the integration processes of an integrated circuit for a microsensor, which can be used in monitoring the initial stability of dental implants and the process of osseointegration of bone-implant interfaces. The substrates used in these experiments were p-type (100)-oriented Si wafers with a resistivity of 5-10 omega-cm. The Si wafers were prepared through an RCA clean process. After undergoing RCA cleaning, silicon carbide was prepared using a high-density plasma chemical vapor deposition (HDP-CVD) system. A PZT thin film was prepared by the Sol-Gel method, and this method was also used for microsensor fabrication. The interdigital electrodes were fabricated by a lift-off process. Properties of the device and thin film were evaluated by physical analyses. Resistance was varied and measured with an HP4145B semiconductor parameter-analyzer to investigate the electrical properties of the microsensor. In material preparation of the PZT thin film, we had to select the best process for our experiment. The Sol-Gel process was determined to be the best for our experiment, because it is easy to control the composition and there are fewer impurities in solution. In addition, it is a low-temperature process, so this can decrease the diffusion phenomenon seen at high temperatures. Furthermore, the properties of the precursors can be varied by adjusting the viscosity and solvent contents, and various electrical properties were created. Based on the above description, the Sol-Gel process was selected for our experiment. According to our investigation by analyses, SiC film possesses high hardness and the preferred orientation after post-annealing. Based on GIXRD analyses, the annealed SiC film possesses the (110) preferred orientation. The (110) preferred-orientation is helpful for surface wave transmission. Compressive stress exists in the as-deposited SiC film. As the thickness increases, the compressive stress obviously increases. The interstitial carbon trapped in silicon lattice sites causes the increase in stress. According to ESCA analyses, the binding energy does not shift before and after annealing. This reveals that SiC films do not react with nitrogen gas in the annealing ambient conditions. The multilayer structure of PZT/Ta/SiO2/Si was investigated, and its electromechanical characteristics analyzed. Ta film possesses better adhesion between SiO2 and the PZT film. In addition, Ta film has an alpha (bcc) structure, which has low resistivity. In the dry etching process, pure chlorine gas possesses a better etching rate on PZT film. The smooth sidewall of PZT film produced by etching with Cl gas was obvious by SEM observation. In the copper electrode fabrication, the 400 degree C reflow process after Ta and Cu deposition was performed to reduce microvoids. The interdiffusion phenomenon of Cu and Ti atoms from the PZT film was not observed with TEM analyses. This reveals that the Ta film is a good barrier against Cu and Ti diffusion. In P-E curve measurements, Pr values for PZT layer were in the range 11.9-28.78 uC/cm2. This reveals that the microsensor possesses electromechanical properties.