¥i· ⁄Jƒ ¡MEMS •L•P·œS †Nfb⁄H⁄u⁄œfi ' ªƒX†s˜ ″°·œ⁄W ⁄S‹ ª o»P †¥ ¿(3/3)

› p e ‰,NSC92-2314-B-038-012
ı ƒ ˙ »92¡£~8 ⁄°1 ⁄ Ø 93 ƒ~7 ⁄°31 ⁄Ø

¥D «ø ⁄H¡GS ı †· › ¥ x ¥ _ ´ · ⁄ j · ⁄ f ~ ´ · |⁄f ~· _ •´ ·‹ª
› p e »P¡GH.›ß fl¤}¥ x ¥ _ ´ · ⁄ j · ⁄ f ~ ´ · |⁄f ~‹ ·‹ª¤s'
‰ † ŒS» ¥ x ¥ _ ´ · ⁄ j · ⁄ f ~ ´ · |⁄f ~· _ •´ ·‹ª

⁄@¡B⁄⁄ ″K›n

¯ ¥ ¥…„g ħı† ÐBz⁄¸ ħı† ÐBz« Æ″SiC"¿ ` ‰⁄¤^ Lƒ] ħı† ÐBz¤˘–oSiC` ‰⁄»P·Æ›

¥»× ª s¥ H »†xy@• L « ‹ « D fl } âƒ¡¥i⁄l†J¥˝` †¡G„ ″G»PSiC` ‰⁄,g•L¤ Ł"·œ « ‹ S⁄œ· ¯ Ø " ″ • Pœ⁄ƒl¥¶¡A@¤B»P , » ' ·œ–o" ″L w« ›¨ † G‹O †¯" ″Cƒ ⁄œ« · ¯ Ø † , ¸ ƒ ¤ • P · œ , „m¡A¥H†š˜A″P˝Tœ⁄£„q` ‰⁄S „c‰¢ƒXfl S°¡A«h ‹ · ¯ ØS·"^ › ' T «⁄·¸`«Æ' ª ƒ X{« ¡¶if PZT £„q` ‰‹ „ "″¯ .|.h †″c⁄ "R¡A ‹ ªs⁄⁄S Q ¥ ¸ " – K „c‹fi. ⁄˘‹ ¤t†¸ ƒA⁄ SO¶if ƒ ¶ ⁄ "R¡ €H"«†zfi ‹ ¤ £n (HDP-CVD)¤ I £″⁄˘"¿(SiC)` ¡ ‰'P«‹ (PVD)"″ ″‰ ⁄ ⁄ fl㜘"¿»PPZT £„qS fi˘ (100)"¿· „ ¶⁄¥A– ¥H• » fi‰(Sol-Gel) S @ ⁄¶¡...h¡A„gSEM˘ ƒ –o" ¡A ″‰⁄»P⁄G "k»s†˘PZT £„q` ‰⁄¡A¤^¥H¿n¯ Øq„ » s{ fiæ⁄˘"¿⁄PZT £„qS fi˘¤ªƒ †u¶V"″" fl – ´ ¶ S⁄G£"k–NPZT £„q` ‰⁄– ´¶' ⁄O¡ €HPVD`Æ "″ ″` ‰⁄,gTEM˘ ƒ –o SiC` ‰⁄⁄W €H–'£ ħı⁄¸S † th⁄⁄Łf¡„ " ¡A ″` ‰⁄‹ ƒh·„‹ ¥B‹ ¤ªS„q" †v"" PZT £„q` ‰⁄¶if ħı› Þ˘PZT £„q` ‰⁄ α(bcc)¯Ø⁄ ¥ ⁄Ł †″c¡C„g¥ |I–· w·œ–o ″ ¤ª £„qfl S°¡AƒA¥ ML..v» s{(lithography) ` ‰⁄„q" ›¨‹ ‹ø170μΩ-cm¡C• » fi‰Yk»s ⁄¸` | "k(lift-off)»sS @ ¥ e«„q•‹¥¡AS„ƒ¤ †˘PZT £„q` ‰⁄,g– ´ ¶ S⁄A¥H ħı⁄Łf¡ " ″ ⁄¥⁄ SO¥H» „¶if ` ‰⁄⁄ ¸ ⁄¥fl S°⁄ ¶if «Æ† Ðz¡ ŒHX-¥œ"″´ ¶g⁄ "R ф{¥HS " R ← QCfb £„ q • L «•P„„œq'¯– ·Q⁄¸ ß † t h⁄«Æ″ £„q` ‰⁄¤ªƒ†PZT‹ ¡A¥Bƒb ƒ ⁄W¡A« hO¥ ″q" ¯ ⁄ ˘⁄¸″|„q‹y·œ„ ‹ PZT £„q` ‰⁄"″»k¤Ł» s{⁄⁄ ф{¡Afbfl´Cl2 ¥D¡C„g« ªs † " G ª¡¥SiC` ‰⁄,g⁄@ p fi·Æ fi ¯Ø⁄ƒ†† ¤¸"″»k¤Łfi˜†v¥B¤ª¥› ª″»k¤Ł fi ħı« ŒHAFM˘ [ „ o ƒ"'œ¯–ƒ† ¡Cƒ „gTEM˘ ƒ ¯ ¥ ¡ ŒHPVD⁄Łf¡`Æ ·„ ¥ Ðs ƒb ƒ† flS 'w "″ £⁄Ł ƒV "″» „q•¥»P £„qS fi˘` ‰⁄¸ ″` ‰⁄‹ ›–'… (preferred-orientation)¡GIXRD¯ ª ¥,g ħı ƒ„¤^ L´ X††{¶H¡A¥ ƒ„–o" ″` ‰⁄fl ƒ†fi˜ «ÆSiC` ‰⁄¤ª(110) £⁄ŁƒV¡C›Ł¤ £n"′SiC " » ` ‰⁄,g400°C"″ƒ^‹ y» s{⁄⁄»P £„q ` ¡ ‰'•L¤ Ł"·œ, » ¶if •L w« ·œ, ¡A¤ S fi˘` ‰⁄⁄⁄ g "˜»P» "″¥ ⁄‹´ X†¡C £„q •L w« › ¿œ« 50 GPa¡C,g` ‰⁄ † Ø¶qœ» • L « •P·œ„ g•¥˘¶q-„q† ı ƒ‰Ù″¶q·œ–o ·œ–o SiC ` ‰⁄"″ *O ›¨‹ £ *O " ¤ Pr›¨ƒbl1.9 ~ 18.78 μC/cm²¡A¥ ƒ„–o" (compressive stress)¡A¥B *O›¨ ¥p« "″…W £„q` ‰⁄»s ƒ ¤ " ″ P·œª⁄¸¥„q‰¢ƒXfi˜ ¥ [ƒ …W¥C„g¥ ESCA¶if ` † ⁄"Ro †¡C " ¡A¥…„g ħı† Ðz⁄¸ ħı† Ðz« Æ″SiC` ‰⁄ ^ ` ¡G⁄œ« · ¯ Ø ¡ A ^ › ' T «¡A» ' ªƒX¡A ⁄S` †fl ¶q¤^ L ¥ƒ⁄˘ ¨ † † †£¡¥A´ fi"k¡A £„q` ‰⁄¡ A • L «•P„œ

Abstract

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 Ω-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/SiO_2/Si was investigated, and its electromechanical characteristics analyzed. Ta film possesses better adhesion between SiO_2 and the PZT film. In addition, Ta film has an α(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 °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 μC/cm^2. This reveals that the microsensor possesses electromechanical properties.

Key words: dental implant, stability,

osseointegration, Sol-Gel method, PZT piezoelectric thin film, microsensor.

⁄G¡B›p e‰t¥ »P¥ ""

ƒ b ⁄ f ~ ´ · ` { Š ¶ É_⁄W¡AŠt¸{⁄Ć„¥-fi¦Å¥Ł"c""^ ‹ ""‹ p]• |... v T¤f ⁄ @ fi M ƒ † fi ~ , ¸ , m ¥ i ¥ H ¤ ŠU ßƒ ⁄Me‹Wv›¨¡ØƒA¥⁄dWf M Wv¤ªf ¶q⁄ ˇ ⁄"R « Æ ⁄ ¸ ƒ b ´ ¡ ƒ X „ L { ⁄ ⁄ ¡ A'‰ŁƒA¥"flS'¸°¡Z‰ŁƒÆ„¥"¥ę~¤ £ ⁄ F ⁄ ª~Š"fi¸·œ „ ·¨ØP¤ · ⁄ J † ¡ ƒ ‹ ⁄ ¶¡'T«œ¥"‹¡Z¥A⁄S.‡vQ ... Šx¥ƒæfb¥´"«´ ·¨"» ¯ ŢC¥ « e ` { Š ⁄ W fi¥ŁX'-æfiyg‰w„†"" ƒ · ¶ ¥ K«⁄ œ‹ · ¯ Ø ¥ JDœE⁄fiŠ⁄Ł "k¡Cƒ ¥H X-ray ¸ œ⁄HØ w † ´‹· y ¥ «‹ «of ¥H⁄U""› ¤ »Pfl°´I¡C†~⁄ ¢AX-ray ...v „† L"k »·œ 30%¥H⁄U"" ' ‰' ¸ƒ‰ Ł ¥¥¢ [1] ¡Af ƒ„ L"kŠ@‹ ƒ ›`¶ É_⁄ ¤ª¡A⁄ ˇ ƒ'„ ' „ ' » ~ Ÿ ¡C¥†~⁄G¡ A ' æ fi‰„u†fVb'w ¶q⁄ W ƒ‹• ⁄ Šx¡ˆAfƒ „„ ' ‰Ł""‹ ¥¢ ¥ u fl ¥w'¡°C†[„T¡ A ' æ fi‰„u†:V¿ fi g ‰ffi†⁄H ØA‹O⁄@" «I⁄J' °¶ É_⁄ Łk¡A ⁄ £ Š Q '"¶ffi"" l ´"·œ¡C†~¥|¡AX-ray ...v„† ~ ' ¶ Q › ¤ ¡A» ø fi "¡'ØA ¤ 'æfig ‰u•‰"¤ œ – o ¥¶¥ †›¸⁄lfl ' e › ß ¦ƒfCA" » „ Š@⁄H› ß ¥»‹ ¤ „L– M • ~V‰fi⁄H ›ß¡Af ƒ„† ¶ ¸‹df ¥ • ƒh› ¤ ¡C

ƒ ¥@" ⁄ Łkƒp Periotest® † £ « ~ ©Š Q¥¸ ⁄ œ ‹ · ¯ Ø ¤ ⁄ O « Æ " " ƒ † – ¡Š ^ › ' T "¤[2]¡C ¥ƒŠ ¸⁄ @ › ‰~⁄O¥ h ‡. » ⁄ œ ‹ · ¯¤Ø¡^A»·œœ ‹ · ƒØ ... † P·Œ" „ fi ¶¡¡A• ° • ¤ ¶A⁄‡.†""fi ¶ ¦U¡A¦ ¥ Hfi„Š @ ‹ ⁄ œ · °¯Ø«" " ¤ ¡ C ƒ ¥o... ¸ ""⁄ Ł " ¥P‹C⁄ j ⁄ p ⁄ ¸ ŁƒjVAŠ¥Y ¤ ¥i¥H ¥ ›p'T' w Ę ⁄C¶q"" „æ¡Af ‹ ¥[⁄fkœ · ¯Ø⁄W""⁄ Ł ƒ V£ƒÆ· N • | – ¤ ™£ƒP " G ¡ Ć]Sfi„Q ¥⁄¶D q Ę ⁄o œ ‹ · ¯ØM¥ŒÉ´· ¥ –ƒ‹ œ ‹ · Ø"(displacement)¡ A Š P⁄ œ ‹ · Ø"‹ˆ¡›ATŠ @ ‹ ‹d⁄œ‹ ¯Ø^ ‹ "‹™A Łk¡A` M‹O¥ « e ¥–™¤£ ⁄ Łk¡Af «of ¥£¤ ‹ Š¥ŁC

ƒ M Wv(natural frequency)‹ " « ‰›Ł ' °(stiffness)»P‰Ł¶q(–K«)"¤ ...ˇ¡Af ƒ„⁄S " ‹ " ‰Ł"" °"A ...ˇ(dynamic parameter) [3,4]¡ Ć"«† z N,⁄qW¡A¥ffl " † ¥XŠ¥"fiˇ o¥ ˝ ¯⁄fi ¡A¤ › Ł°«Y..ˇ»P–K« ¯ ⁄ˇ" "¡ , ¡CŠ Ę¿fi¶ °† ‰ Š @ ⁄ f ~ ´ ·¥"ª¤us ¤ª¡A⁄j†⁄¥ ¥H⁄ ‹ ¤ ⁄j ¥¥¿ ŁV¡G⁄@‹ ⁄œ ' ‰⁄" ¢A"– ·Q¡A⁄@‹ ⁄ œ ‹ ·»P¯Ø‹ ' † ´ · "D » œ¡Noyes ⁄¸Solt ‹O› ¥ ŠQ ¥¿fi¶ °† z ‰ –·ƒ Q M¥ ¿ ⁄ ⁄` ƒ ª«"" · " [5]¡COka ¥HŠ Ę¿ ƒP""› †z ofii⁄@fiM¥] ¥ˇ¡ Æ¿¥ H »·œe'P¶ ª a" ¢A»P⁄œ ƒ"" •n « [6,7]¡COkazaki ¥H«hŠ Ę¿ƒ„† ‰ ⁄ æß⁄ "Rƒ M⁄œ'P¶ ª a»Pƒ Ú ⁄H⁄u⁄œ'P¶ ª a"¶fi¶ °flS'°[8]¡C Lee ¥H"‹ ªs‹O›"ƒ,Š Ę¿ƒ M Wv‹ ...ˇ¡ ÆØ¥ ~ ª ƒQ M⁄œ'P† † ´ · "« o¥ ˝ ¯⁄fi ƒ M Wv›¨""¯ ⁄ˇ¡ Ć‹ † o ‹ ªs⁄¡A o† { † ´"‹ ""¯ ⁄ˇ»Pƒ M W ¥⁄¶Š¡· X ĘŠ‡e{‰u' °""^ «Y¡A¤^^ 'œ Š Ę¿ƒ M WvŠ @ »œ⁄œ ƒ'P† ' "‹ "" u¶V' °[9]¡C –Ni¶ °† z ‰ ¥¿ƒb⁄ œ ‹ · ¯Ø"" ⁄ œ ‹ · ¯ Ø ¤ ⁄ O « Æ " " ƒ † – ¡Š ¿¡Æ¤«kŠ@Q"æ·Xƒ‹d"¤¡C Kanoko Š Ę¿fl ‰˜†£ ¥˝ „ Ę ⁄o œ ‹ · ¯ØŸ"¶ T (harmonic response)"iŠ⁄ R -· ¯Ø(bone-implant) ‹ › – P †"" ^D[10-14]¡C ƒ ¤ ª¤sjf h ‡k› › ' fi „ˇŠ "¿"– ·Q¡A„ 'ffĆ¶ Wv¤^¥ ... ¥¡C Meredith ¥H«h¶i⁄@¤BŠ Ę¿¥¿'¶"i¿E o⁄ œ ‹ · ¯Ø«ÆE¤ ""ƒ@fi¶ Wv› ¨ ⁄ "R"R '–· ¯Ø ^D¡A¥L o†{ƒ@fi¶ Wv'M'T« ø{« ƒ†« ⁄j""^ «Y[15]¡C– ¥L¤^Š Q ¥¯Ø " Ć¯ ¥ ¥H¯ ^ [16,17]¡C

· ƒb„ Ć⁄ Ł R⁄¡WAƒ M Wv‹ O Ę¥¸ fl ‰˜†£¥˝ „' ¿¥ ¿¥¿'¶"i¤ ¿ E o '†c"«""fi¶ °flS'°(¿ fi¶"k, harmonic response method)¡A' ¸Š Ę¿‰ ˜»"l⁄@ƒ,¿ Eo' ƒ†"" W

†v(‰ ~ »"‚kimpulse response method)¡ A ÆSQ „q ¤ t †¡]Micro-Electro-Mechanical ¥ ¸ S † t † ¥ „(Fast · «Fourier System, MEMS¡" " ª¤»»P cfii¥ 'œ¯ªf aW Transform)¡A› p " ffi¶vjWC W »S Œ¿fi¶ ¥[¡A• L „q‹‚¥ " "cfii–N• |ƒ ¤ ¥..¤ ª¤s ° † z ‰ ‹ ª ¤ s ‹ œ ‹ · S Œ"¿‹fi¶¤sS¡‹"C¥ Dy¡Af ¤ ‹Hˆ ¥"‹ ¡‹' ‹£¥ 1 ¿fl°" "@ "k¡ C M ƒ¿"k¡¶ ‹ @ ¶ O fi ¥Bt‚W" ¿fi˜ ‹ j ¶¥¡G ¤ ·¥HMEMS S †N' ¥ †£""• Ł, "k¡A' „ ' „ ¥ † ¶ • S ¯ ¿E†v«"iSfi‚f"‚ W¥ ¥ ¡A• L «•Ðe „¡]microsensor¡^‹ ¸ Ł«‹ ‹ ~ fl S „ ƒ ¤ ‹ @ › · œ , ¡ C æƒ~¤ »P]‹° „¡q‚microactuator¡^ ¥[24-26]¡Afb¥"´ ¡B " " o„F A Œ¥‰ ˜»" l ‹ @ ƒ , ¿ E¤†'v"ƒ† W fl Ł ¡B¤ ¶fi¡B ‹u‹ ¿fi¶¶O' °„q‹ l†£«~ ¥‹Ł ‰ ˜ »"k w , g ¤ œ ¥ N ‹ FW"k„[4]"¡C fi¶ ›–ƒ fi† †¥ ¸¡C¥ ' ‹‹œŁ›–""‹j·T« `Y‹p Okazaki ¥H« O›"ƒ,S Œ¿‰ ˜ »"k ª ¤‹œƒ »P»s {B† , ¸' M S@‹ W"› »¤ ¡Afb•P·œ „ fi ¶°fl S°""‹H¡A¥ Ł S Œ¿‰ ˜ »"k E o‹œ »P›P ° „‹Ł›–¡A» ›n–˜¥ ¸£ƒP' ¶·†¸""¯X ƒ¡A¤ ¥ ' – ¤ " "W†v¯ T†(frequency ‹Łƒ¡‹ ˇƒ ¶} o•s" " ‡‰« [" c¡C• L „q¤t response)„ˇS¸‹ "R‹œ' P ¶ · – ‚fib‹OW"¤‹ †¸fb‹uS@fi ¡A›"¥ ‹ O›n•P" Œ¶ D" „ ‹¸ ƒ ¡A¤ˆ´ · ƒ „ß›fH‹ ¤œ' P ¶ · – a ‰‹"F" ˜‹"¤ ¯ ‹ˇ¡A Mk«Æ¡A–N „ "'fl S°' ¸¤ ¯ ‹ˇ"" " †{¡AS@« †]›p‹H‹uS fiˇ""› « › ¤ ...[8]†C ‹j‹p¡A¶ · e „–‹¤ (•L†B†z „' „ ¤£) Elias ¥H«h« O›"ƒ S Œ¿‰ ˜ »"k ‹ "R '– †B†z¡A¤ˆfi †B† ‰" "G¡A¥ ›P ° „¤ o · ¯Ø« ›–"" ·" [18]¡C M¡Af MW†v¶q·œ ¥"‹@¤· °S@¡C• L „q¤ t¸ „ ""•P·œ „·N« "k‹ S fl´¡IAfb' ¶q¤œƒ MW†v""„ L {‹¡A • ' ‹H""†·¡Bƒ ¡B» ¡Bƒ ¡B¥ ‰S ¥‹ ›x¡C fi ¶°, „m¥†¥ SCfi ¶ ° W‹@¤B‹@¤ B – ‰yƒ ¥ ' • L „q¤ t¸""‹ ¤¥» »N« ‹p¡A' "fi ¶ ° W ¡Afbfi ¶¡‹W¤ˆ‹ £ †ƒXg fi˜ ¥H¡A•P·œ „¥»¤ »""‹ ‹o‹]›n¤D« ‹p¡C¥ ¥~¡A †¡C¥ ¥~¡Afi ¥ »Œ"æ·«' ‹ S ˆ †z„L• Łp‹˜¡A £‹F«Of†¥ ƒ ¤ ""•P" fl S° « ª s¯ ¥ ¡A‹œfi · ¯Ø‹ S MW†v• | ¥ ‰Ł ¥H¥~¡AS ƒ††\fh u´I¡Afp‹˜ †S ¡B‹uS@ W ¶ qBS ‰ Ł ¡ B ‹‹o'¡B¡ ƒ X S {¥ƒ]fl ‹S –a¥[...e¡B"¯¶¡, "R« "‹ ¸SCf¤¥» ¥¡Af ¥B ¯ ‹˜ƒ S¯¡A† o ¤…¬VTƒ MW†v¯ ‹ ˜Sƒ] S ' ·…‹…¸q Œ]ƒ„¡A• L «•Ðe „‹O¥..¤ •P fl »P‹œfi · ¯Ø^ › ' T « ‹S¦°‹ẁ† ~ †Q, ·œ „"'¥ Dy[27-30]¡C † ← Q[19-23]¡AfpHuang ¥H" "Ø¥~« ª s † ¥ ' ƒb•P·œ› † zW¡A• L «•Ðe „‹j†£ "G o†{¡ A Œ¥.¸"A· œ , "‰" ~ »"k E œ«‹ S Œ¿¶·† ¸ ƒ•Ðe „‹ ƒP‹Sƒ U ""¦kz/‹˜ · · ¯ Ø@«fi¶¥ H « D – ~ ƒ¡S¦@«S J»•œ T •P·œ› †z¡A¥ufb‹ ‹o‹W¥ [¥H` Y‹pƒ ¡fib ,„" "Łƒ¡¡A¥ ¥Hƒ fi˜ »·œ¤ ‹ œ « · ƒØM •P·œ „• Łp‹˜""„ L {‹'‹ S Œ¿""ƒ Ù »s S@ W†v›¨¡A¤ˆfb‹£ƒ P « ‰ " « ¶‹ ¸'´ ƒX ‹Łƒ¡¡Af † « ƒh¥ Cf¤.. ¡B¥i‹j¶q»s S@¥B• L « fi ƒ«ƒn""˜ F « ¡A¥B‹£‰ Ø¯Ø"„Œ ‹p‹S¿n¯ Øq, »s {S †N›l¥"ƒ ¤ [31-33]¡C ¯ ¡B¯Ø¥ ~ Œ¯' ¸ƒ†› ›,fl … ‹ "R"" "G ƒ b Sfi‹W¡A«h‹j† ¥ ¥H"¿‰ŁS fi˜« ¥D¡ Œ] S¡" †{¥Xf„‹Ł"k"" ¶V' °¡ C Mf ¡ L"k ƒ ¡A• ŁP·œ „‹j† ¥ « " ¿ S •P·œ „ » ¯S' ‹ f˜¥ B ¥¶• L p«‹ˇ""¤ ¶ ¥q‚fo¤ (silicon sensors)¡Cfb" ¿ "O‹W "'"¥t‹ @ « · ¯Ø S fi¶° T , †£›¥P‹ ƒ‹""•P·œ, „m fn†B« O¡A¥i–N„q, ‹] fbfP‹@· „ø‹WSY¿n †]›p¡A¤ · ‹‹·L‹H· £¸¡C ¯Ø‹(integration)¡ C Mf¡A„ « fh" ^ ""•P ·œ „ƒ ¤¥¡A" ¿ S ¥»¤ ›¤^‹£‹ O† ¤¸""S ƒ H « S ""‹ Øq cfii¡A‹H^ " " ª¤s fi˜¡Af]ƒ„¡A¥i• ft¤ ¥ƒ¥\fl ' °S fi˜ƒ ƒb ˜†¤‹‹ wg¶V¤ ¶ V ˜ƒV • Łp‹˜"" "fc¡A•L

(1) [illegible]

(dipping) [illegible] (spinning) [illegible] (spray) [illegible]

[illegible]

(PVD) [illegible]

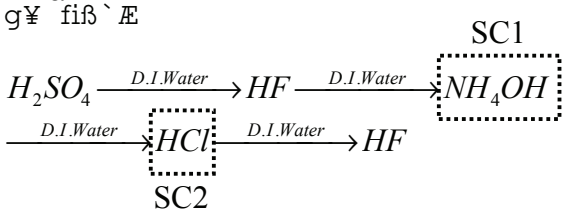
[illegible] (h_{IDT}) [illegible]

[illegible] (1) [illegible] 1.7 [illegible] -cm [illegible] 2.7 [illegible] -cm [illegible] (2) [illegible]

[illegible]

(1) [illegible]

[illegible] (native oxide) [illegible]



SC1 [illegible]

[illegible] NH_4OH [illegible] H_2O_2 [illegible] H_2O [illegible]

[illegible]

SC2 [illegible]

[illegible] HCl [illegible] H_2O_2 [illegible] H_2O [illegible]

[illegible]

$$M + xHCl \longrightarrow MCl_x \longrightarrow M^{+x} + xCl^-$$

[illegible]

(2) [illegible]

[illegible]

» P fi æ " " ƒ ǂ -TEOS" « • » ¡A¥» ¤ › ƒ b « · ⁄ " – ` £ ⁄ U ‹ †40 Ø¡A, g¥[.acetate¡] ~ 70ºC¡A¥ H „ F ¤ ¡'M H TEOS ‹ ¥D" "SiO_2 LPCVD ⁄ ˇ ƒ¡ƒ G (TEOS) $Si(OC_2H_5)_{4(g)} \longrightarrow$ $SiO_{2(s)} + 4C_2H_{4(g)} + 2H_2O_{(g)}$

(3) " ⁄ ¸"¿` ¡‰⁄"¤H¿n

‹ · £ @"1¶ · W † v ¡ A ¥ »ª¤s S Q¥ ¸ HDPCVD¤I¿nSiC` ¡‰⁄' P«‹(100)"¿ · „ ¶ Œ ⁄ W ¡ H"¿T¥k ⁄ ˇ ǂ fi¯ØƒP fi ‹ „ q … † ¥˝ƒfA¯S Ø‹ " ⁄ ¸"¿"" « e ¯ X »¶¤H¿n¡A¥ H … W 1˝"'"¥1S¡ ƒ ¥fi(Mean Free Path)¡A¤ˇ„ q – K −o¥ H ¥S¥BS¡⁄ ƒa¶ ƒ , ´ ¡C

(4) ‰w‰˜…h(buffer layer) "ˆ ¡‰⁄"¤H¿n

‹ … W ¶ i £ „ q S fiˇ»P‰⁄G"Æ⁄ˇ"¿ " ' ° A ƒ.bƒ„¡‰G¶¡¤H¿n "ˆ ¡‰⁄ S @ ‰w‰˜…h(buffer layer)¡ A › S £„q S fiˇ t ı › Pˇ(thin layer-buffer) † " c " " † { ¶ H ¡ C ƒ " ¡‰⁄‹O¥H"ˇ (magnetron sputtering)"" ⁄ ƒ¡¡A ƒ b fi"¯ « 5¡10^{-7} Torr ⁄ U ¶ƒ10 nm «p« "¤H ¿nƒb⁄ G fi æ ˃"¡C W

(5) £„q` ¡‰⁄"¤H¿n

¥ H • » fi ƒ‰"k`Æ⁄ j • S ¥ i ⁄ƒ¤¥| › ¤B › " ¥ ¥ H …⁄decomposition¡ ^ ¥ £ ˇ ¡G❶•»† G ⁄ S ¡A❷` ¡‰⁄ƒ b S ⁄W ⁄S† Q—¡A❸ S C¯⁄S fi P… , (pyrolysis)¡ AM❹ " • ¯ ⁄ S †„»P‰o−K ⁄ ˇ¡C ❶• »G⁄S‰ »s » s S @ £ „ q ¡‰⁄Pb(Zr$_x$Ti$_{1-x}$)O_3 ⁄ S ¶ t g ˜ q · „ fi £ „ S fiˇ¡A„C¯‹O¥H 500~800 °C " • ¿N ƒ¤ , m S t ƒ ǂ ' » " Pb, Zr, Ti¡^ " " „ w ǂ•»A¤G ƒ ¤ ⁄ ⁄ S Lead acetate¡] L »„¡APb$(CH_3COO)_2$ $3H_2O$¡^ Titanium butoxide ¡]g ⁄ BJ ¡A Ti$(O(CH_2)_3CH_3)_4$ ¡^ ⁄ ¸ Zirconium acetate¡] Zr$(OH)_2(CH_3COO)_2$¡^ ƒ •» fl ǂ ¡ ¥ «h2-Methoxyethanol ¡]⁄ G ¥ ⁄A¡A$CH_3CH_2OCH_2OH$¡^¡A ¥ t ¥ ~ ¥ ‹J"A¶Formamide¡]¥ » i¡A$HCONH_2$¡^¥ H £"„@ w ǂ ˇ »†G¸"" ° ' ° ¥ H S ‰¡‰»"s S–@CB ˇJ¥ −N Zirconium acetate »P Titanium butoxide •»' 2-methoxyethanol •» fl ⁄ ‹A¤ ¥ ¸ǂ~‹ −N„ w ǂ ˇ»†G ˜¤–N„] "" ǂ⁄ •», ¡AƒA¥ ‹J Lead acetate 'T ¯Ø¡A ǂ «ÆƒA¥ ‹J Formamide ¤ S ‰` ¡ ‰ ⁄ " ›" ‹"p¤ˇ` ¡ ‰ » ¥→ª¡A¥H` SK ` ‰⁄† £ ¥ ˝ı†C", g¥[… 150 °C ¥¯ «ÆS ¥i¡C

❷` ¡ ‰ ⁄ S` Æ

S Q ¥ ¸ ¥ œ "ǂ]phEotoresist spinner¡ ^ ¤ˇ¥ ¸ −`Æ k ƒ b " O W¥H¤ Æ¥‹q ⁄ Ł¡` Æ « e › z ' t ƒ n " „w†ˇ•»†G¡C†ˇ ⁄ @ q¥1000 rpm S C ´ǂt `Æ10 ‹ ¡A ¤ ˇ „ w ǂ•S»†G⁄ ^ ⁄ SG†¡AƒG‹ ¥qH 3000 rpm "´ ǂt– `Æ25 ‹ ¥H– ¤ `¡ ‰⁄"« ¤ ¡C– `ÆS „ ƒ«ÆA– N , ø,m' ˜ ¶ ¡]furnace¡ ^S @ … ǂB¡†]z. ⁄ , ⁄ ¸ h ⁄ ǂB¡†ˆz¡A¥H¤ ⁄ ` ‰⁄† £ ¥ ˝ı†C"

❸` ¡ ‰ ⁄ ⁄ S ǂB†z

¥ H ⁄decomposition¡ ^ ¥ £ ` ‰⁄⁄⁄Sƒ ǂ ƒ¤ ¡ ÆAA¥H h ⁄ „L { ¡]annealing¡ ^ǂ B † ż¡‰⁄ǂ ⁄U⁄S L ƒ¤⁄ ¡A¥HS Q ƒ¤" ł ¥¤ª ǂ £ q'⁄S¶t g ˜ q · „ fi‹⁄⁄¡.C¤ ⁄,¥ h£· l"" ƒ ǂ ƒ¤ ¡A¤ ˇ £„q ‰⁄−o¥H› « ‰− `Æ¡A.. ¥[` ‰⁄" " « p «¡CƒH1ǂ ¥z«h ‹O¥H 500~800 °C " • ¿N ƒ¤ ⁄ ¡A¤ˇ⁄S¥˝ƒ¤¤ª ˇ £qƒ¤⁄ "˝Łp g»˜ „]· „ fi ‹ ¡CƒH1ǂ ¥z« S ¸ƒ¤⁄S £q ` ‰⁄""• ¥ ⁄ ˇ ⁄ Ł ƒ ¥ | ƒ¤' MS¤« ⁄ ŁV¡Aƒ] ƒ „ ƒ»A¥~¥ „q† ı S @ ¥⁄ˇ⁄Ł

ƒ V ‡ ‰z ¡C

❹ " • ¯ ⁄ § † „»P‰o–K⁄ˇ

⁄ w , g … ⁄ , ‡ B † z ⁄ § ¡‰⁄¡A⁄·»‹ ›ˆƒ¥A¥Hnƒ»‡˜' °"" v» ˜(HNO_3, pH<2)

" • ¯ … ‡ B † z ¡ A ¥ H « ‰ˇ` ¡‰⁄ƒ¤‹ »P ˇ B›n""fi ⁄ (NH_4OH, pH=10)¤ ^ ¡A

· „ ¯ Ø " c ‡ y ' M – o ¤ , ‰o–K⁄§•L ¥"[fbCT⁄"g ¤ ¶ƒ‹ ª i¡Aƒ » „q•¥""

• ¯ ¿ N † " " " c ¥ D n‹O a«D·„‰Ł""⁄k „"q•¥""¥ N„ƒp„ˇ⁄@' ¥ ¡C

" ¢ ¥ (viscous flow)'M› ⁄l""´ X†¿N

† ¡ C N «‡•¥¯D › ṁMƒ¤ ¤ t † ¡B › fiˇ

" ^ ¡ ‰K¥M⁄ ‡¯‡ t † ƒ‡¡ˆC ¡‰⁄

†„⁄ Ł →«ḥM § "^… ¡B‰†„z L{

⁄ ¸ §» P ` ¡ ‰⁄§…¨ « ¥ˇƒG‡ˆ

(6) PZT ¯K„q` ¡‰⁄""»k¤Ł

¥ H • » ‰"kPZT •»† G – ` Æ , ⁄ø

⁄W ¡ A , ṁJ¥H650 °C ¿ N † ⁄ @pfi ¡C

, g • L … v » s {w¡Aq„ˇƒ‡`«Æ"i

„q… »k¤Ł (ANELVA ILD-4100, Helicon Wave Plasma Etcher, Anelva Corp., Tokyo, Japan.)¶ ƒ »k¤Ł¡Cƒp„ˇ

⁄@' ¥ 44 ¡A § C £¡‰q…"– K « ¡Bƒ

° ⁄ ˇ ¡ ‰h(mũuftj-chamber)⁄§»k¤Ł

¤ ‡ ¿¡C»k¤Ł– ¥ ‹ fi g ₩\†900 W,

£¥ †v250 W, ⁄ §@ £⁄O4 mtorr,

fi ¯ Øy¶40q sccm¡C‡ «Æ¥H" › ‰ „ł

⁄ ℞»(surface analysis)¶q· œ »k¤Ł

†v⁄ ¸ ‰·ƒ¡„q⁄ Iª•LˆŁ(SEM)ˇ ƒ , g

»k¤Ł«Æ""" ›–¡C

(7) » " ˜ ‰u""„q•¥»s§@

⁄ ˇ · – æ ‹ ª ¿ i " k ¥ ¥H⁄ ‹ ⁄ ˇ · » k ¤ Ł ¤ ‡ ¡ ⁄ ¡ C –æ‹ª¿i‡¡Ł¡‹Ø fl„⁄ø¡Cƒ„¥˜¡A ⁄ F fl └q

‹ ⁄ (slurry), ¥ [⁄ ƒp(silica)' ¸T

⁄g(alummina) ¥"‹ ª i' °(abrasive)""

• L † ¡ A ¤ ^t¥"X Æ»P´ ‡ ‡A¤

¶ i ƒ ·„"⁄ª i¡ A ‹ ª ⁄⁄""‹ ª i`ß

† ⁄ ƒpfl0.1~2.0£gm ⁄ ¶¡¡Cƒ ⁄ ˇ ·

» k Ł«h‹ O¥ {J⁄ @ ¤ »˜"Þ• »Gfp† Ł æ

⁄ˇ„[(KOH)¡ Bv»˜(HNO_3) ¥¤ ¶ƒ¡C

• CMP """»s {fb¶ ƒ fi¡ A „ · ø'

‹ I¥[""£O» P ª¿ƒ¡ ""– ´ ‡t† v N•|

… v̄T¤ ‹ ª i‡t†v¡Cƒ ‹ ª i» ' ¤¥"¸"

⁄ w , g … ⁄ , ‡ B † z ⁄ § ¡‰⁄¡A⁄·»‹ ›ˆƒ¥A¥Hnƒ»‡˜' °"" v» ˜(HNO_3, pH<2)

" • ¯ … ‡ B † z ¡ A ¥ H « ‰ˇ` ¡‰⁄ƒ¤‹ »Pˇ B›n""fi ⁄ (NH_4OH, pH=10)¤ ^ ¡A

· „ ¯ Ø " c ‡ y ' M – o ¤ , ‰o–K⁄§•L ¥"[fbCT⁄"g ¤ ¶ƒ‹ ª i¡Aƒ » „q•¥""

• ¯ ¿ N † " " " c ¥ D n‹O a«D·„‰Ł""⁄k „"q•¥""¥ N„ƒp„ˇ⁄@' ¥ ¡C

" ¢ ¥ (viscous flow)'M› ⁄l""´ X†¿N ¥H•» ‰ƒ"k»s‡ˇ PZT £„q` ‰⁄•»

† ¡ C N «‡•¥¯D › ṁMƒ¤ ¤ t † ¡B › fiˇ †G, ¥g ¤ ¶ ¥ q§‡t– ¶ ""⁄ £¡–N•»

" ^ ¡ ‰K¥M⁄ ‡¯‡ t † ƒ‡¡ˆC ¡‰⁄ †G§ ‹ˆ– ¶ ' "‰ƒiæˇ"¿ † †

†„⁄ Ł →«ḥM § "^… ¡B‰†„z L{ " eW¡AƒA¥H"" 650 °C ¿N †• ¤ ¶i

⁄ ¸ §» P ` ¡ ‰⁄§…¨ « ¥ˇƒG‡ˆ ƒ "• ¿N †¥H§ ¸ ƒ ¤ ¶ g˜"q c¤^

¤ˇ¤ ª ‡¤"¸" „q´ · ‰§'°¡C »sƒ¤""

(6) PZT ¯K„q` ¡‰⁄""»k¤Ł •Ł« ‹ • P · œ „⁄•¥ "ę¡B ¯ |†"c

¥ H • » ‰"kPZT •»† G – ` Æ , ⁄ø "/" ¤z'‰Ł¡B –æ'‰ Ł¸ „q'‰Ł""

⁄W ¡ A , ṁJ¥H650 °C ¿ N † ⁄ @pfi ¡C ˇ ƒ ⁄ §O¥H› ⁄l⁄O¯ª•LˆŁ(AFM)

, g • L … v » s {w¡Aq„ˇƒ‡`«Æ"i ˇ ƒ ' ¤ ‡n` ‰⁄""· „ † ⁄j⁄p" ›–

„q… »k¤Ł (ANELVA ILD-4100, † °W« ¡A¥H‹ †z ƒ¡„q⁄ Iª•LˆŁ

Helicon Wave Plasma Etcher, Anelva (TEM)ˇ ƒ "I›–¯ª•L "fc, g h ‹«Æ

Corp., Tokyo, Japan.)¶ ƒ »k¤Ł¡Cƒp„ˇ ‹ ›–› ⁄l´ X †–§¸¡A¥H§ C –¤⁄X ¥œe

⁄@' ¥ 44 ¡A § C £¡‰q…"– K « ¡Bƒ ´ ¶ fi›¶ ƒ (GIXRD)„ ¤ ‡n` ‰⁄·„

° ⁄ ˇ ¡ ‰h(mũuftj-chamber)⁄§»k¤Ł ¯Ø "fc""⁄ "R¡A¥H‹K' „ " i ¶ fi˜§@

¤ ‡ ¸¡C»k¤Ł– ¥ ‹ fi g ₩\†900 W, ¶i⁄@¤ B ¬ ¡Q¥H" ›–‰ „ł⁄ "R» ¶ ƒ

£¥ †v250 W, ⁄ §@ £⁄O4 mtorr, «D ¥ƒV' ° fi» k‡Ł` ‰⁄" ›–‰ „ł¡A¥H` ¡

fi ¯ Øy¶40q sccm¡C‡ «Æ¥H" › ‰ „ł ‰⁄·„ ‡⁄O¶q·œ» ¶ ƒ ‡⁄O¶q·œ⁄ §O„

⁄ ℞»(surface analysis)¶q· œ »k¤Ł `Æ‰⁄«e«Æ· ø" ›–""ƒ–†v¯ ⁄ˇ¤ Ðo

†v⁄ ¸ ‰·ƒ¡„q⁄ Iª•LˆŁ(SEM)ˇ ƒ , g ` ‰⁄„ § "" ‡⁄ A´ ¥ †@•L¤Ł†"·œ

»k¤Ł«Æ""" ›–¡C , (nanoindenter)¶ ƒ ` ‰⁄"" w‹ ¶q

·œ¶Aƒ „w‹ ›p¤ ¥¸› ¥¿› ¿n«Æ⁄§ £⁄l

(7) » " ˜ ‰u""„q•¥»s§@ (nanoindenter)PA¥H‡]w‡t« ¡B..W¥[£O""

⁄ ˇ · – æ ‹ ª ¿ i " k ¥ ¥H⁄ ‹ ⁄ ˇ · » k ¤ Ł ¤ ‡ ¡ ⁄ ¡ C –æ‹ª¿i‡¡Ł¡‹Ø fl„⁄ø¡Cƒ„¥˜¡A ⁄ F fl └q

‹ ⁄ (slurry), ¥ [⁄ ƒp(silica)' ¸T »s§@""⁄ ¥ ⁄⁄† f œ¥„Xq' °"", ˜⁄¸

⁄g(alummina) ¥"‹ ª i' °(abrasive)"" ‹ ^ T¡fA§ ¶•¤ ¥¸ƒ °⁄ˇ""¶q·œ¤t

• L † ¡ A ¤ ^t¥"X Æ»P´ ‡ ‡A¤ † ¸ §U–o †"G¡A„q‹y–„q £

¶ i ƒ ·„"⁄ª i¡ A ‹ ª ⁄⁄""‹ ª i`ß (Leakage Current–Voltage, I–V

† ⁄ ƒpfl0.1~2.0£gm ⁄ ¶¡¡Cƒ ⁄ ˇ · Measurement)""flS' °‹O´ ¥ HP4156

» k Ł«h‹ O¥ {J⁄ @ ¤ »˜"Þ• »Gfp† Ł æ §„ƒ¤¡ ¥H Keithley Model 82 CV

⁄ˇ„[(KOH)¡ Bv»˜(HNO_3) ¥¤ ¶ƒ¡C Analyzer ƒb1 MHz W†v⁄U§@‹ ¶q·œ

• CMP """»s {fb¶ ƒ fi¡ A „ · ø' ⁄u ¤ª ¡A ¶q ·œ „q fie – „q £

(Capacitance–Voltage, C–V

Measurement)ƒ – ‰ u ¡ A ¤ ^ ´ ƒ„¤D¥X‟”¡‰ o†{¡A ћı«Æ¥i' ōêª‹ ¤ Ş ‹^ ⁄ ¶ q›(dielectric constant) ¡ ŒH Bio–Rad QS300 ł ¯ ¥ , › ´·‰«¥n¥~ ^ » (FTIR spectrometer)¤ ¯ † ẇ` † ¥ ¡Cƒ„ †‟G–Nƒ ł Ş Q' '„«Æ ŝik¤Ł‟”¶i ƒ ¡C‹ ¯ †w, g ‟•¯¿N †«Æ' Ş ¿ƒ¤ ‟fc⁄ ¿ ‹ ‟”¯ ⁄˜¥HX ¥œ´ ¶lg» ¶ ƒ ⁄ ‟R¡A» „¶q ·œ¥Hƒb« •¯⁄U¥H1.543 Å ⁄ ŞCu „vK£\¥ ĉ— ' 20¢X 60¢X £c⁄2£c.. ƒ ¡¶q·œ¡A¤œ..¸¶ „j ‹ 0.02¢⁄XA– ‰¸†t« ‹ 2¢⁄xmin¡C, g X ¥œ´¶ fig» ⁄ ‟R o†{PZT ‹ ⁄w¥˝ƒ¤¡A¤ †‟Gƒp„˜ ⁄Q' ¥ ¡Cƒ„„ PZT £„ q ¡‰‟”«~‰Ł¤ª¥¿›– ‟”Ş fl q¡C„˜⁄Q⁄@‹ PZT/ ”‰⁄⁄ fiæ⁄˜‟ ¿ ¯| ‟c¥H†ı ofig–‰·yƒ¡„q⁄l¯ª•LˆŁ⁄ ‟R ‟” †‟G¡C, g †‟G–o‟ PZT £„ q ¡‰¥H 650 °C ¿N †•¯« ¶ ƒ ‟•¯¿N †Ş ¿ƒ¤‟” ¶ t g˜q ‟fc»P ”‰⁄⁄ ¿ fiæ⁄˜‟¿¤ª' ōêª‟ ‹ ›–¡Cƒ g » ˜]Łfp„ q ¡‰‟”»k¤Ł⁄Ł‟k ‹ O¥H Cl_2 fi ¯Ø⁄ ¿ BCl_3 fi ¯Ø† ¥X¶ ƒ ŝik ¤Ł¡C o†{fl´ Cl_2 fi ¯Ø»k¤Ł⁄Uƒ†† ¤ ¿‟”»k¤Ł fi˜†v¡C»k¤Ł«Æ‟ ›–¥uƒ†⁄ ¶q· fl‟¡K„˜⁄Q ⁄G‹ PZT £„ q ¡‰⁄g P-E ƒ ‰u¶q·œ‟” † ‟G¡A¥ » Œ¯‟” £„q•L« •P·œ „„g•¥⁄˜¶q– „q†ıf ‰u‟”¶q·œ–o‟ ¤ Pr ›¨ƒb 11.9 ~ 18.78 μC/cm^2¡C„˜⁄Q⁄ ¥H†ı ofig–‰·yƒ¡ „q⁄l¯ª•LˆŁ˘ ⁄ •L«‹•P·œ „‟”› `Ł † ‟G¡C˘ ⁄ †‟G¯ª¥ 1.2 μm ⁄æ 0.6 μm ‟”‰u¶ Z fl ł·⁄ß¥Bƒ¤¥\†v, ß ‟¡C„˜⁄Q ¥|‹ , ⁄ ˘· – æª«Æ‟”¥ ⁄ « „q•¥¥H AFM ˘ ⁄ ‟⁄‟ ›–… ¥†¡A, g⁄ ‟R–o‟ IDT ‟”» „q•¥⁄¸ PZT £„ q ` ‰⁄¤Łƒ]⁄ ˘· – æ ª¿i ª˘ƒł‹ ¿i„ k ‟”† ¶H o¥˝¡C›f‹ª ¤s, g¥ fi ¶ ° ›†z»P` ‰⁄Ş ł N¤^ †ƒX¥ ¶i¥b ¯Ø» s{¡A⁄w¥iŞ„ƒ¤⁄@•P·œ⁄ ¥ ¡C¤^, g¥ „q‰¢ƒX‟”fi˜ ł† ¥˝ T„¡A, g•¥⁄˘¶q„q†ı ƒ ‰u‟”¶q·œ–o‟ ¤ Pr ›¨ƒb 11.9~18.78 μC/cm2¡Cƒ„ †‟G‟ ¥ ƒ„‟ ›–` ћi⁄ ¥ 'M¿n ¯Ø„q, ªƒX–N¥iƒł fi˜ ß ƒ -˘⁄œfi · ¯Ø^ ‹ –Ł¥ ¯ ⁄˘„ ¤ ^ ›T« ⁄Ş..v¯T¥i˜ ≈ ‹ª o

¥|¡B †‟G»P Q‰

„ ˘ T‹ SiC ` ‰⁄, g £ƒ•¯« ћı«Æ¥H AFM ˘ ⁄ ‟”… ¥†¡A SiC ` ‰⁄, g⁄ @ ⁄ fi fiÆ ћı«Æ¥H AFM ˘ ⁄ o†{‟ › – ƒ'œF·ª„ ¥ B ƒ s ŝƒł†flŝ ‟” u ¿ ⁄ŁƒV (preferred-orientation)¡C„˜¥|‹ SiC ` ‰⁄, g ћı«Æ¥H GIXRD ¶ ƒ X ¥œ´ ¶lg⁄ ‟R«Æ‟” ƒ – ‰¡A›o†{, g h⁄«ÆSiC ` ‰⁄¤ª(110) ¥g ⁄ ŁV¡C„˜⁄ × SiC ` ‰⁄«p« ⁄¸` ‰⁄ w« ^ «Y„˜¡A› Ł ¥¿ŸSiC ` ‰⁄' • ŁŁ·tœ» ¶ ƒ •L w« ·œ, ¤ •L w« ›¨‹ø‹ 50 GPa¡C„˜⁄» SiC ` ‰⁄«p« ⁄¸` ‰⁄ ł O^ «Y„˜¡A, g` ‰⁄ ł O¶q·œ» ·œ–o SiC ` ‰⁄‟” ł O›¨‹ £ ł O(compressive stress)¡A¥B † ⁄O›¨ H«p« ‟”…W¥[ƒ …W¥[¡C„˜⁄C‹ SiC ` ¡ ‰⁄, g h⁄«Æ¥H⁄ ˘ ⁄ „‟R˙ l ⁄‟R (ESCA) ⁄ ‟R«Æ‟”ƒ – ‰¡Ag¥ ESCA ¶ ƒ ` ł ‟R –o‟ ¥…, g h⁄ŧ ¥z⁄¸ ћı† ¥z«Æ‟”SiC ` ¡ ‰⁄⁄Ş` †fl ¶q¤^ L ¥ƒ⁄ ˘ ` † ††£ ¥˝¡C„˜⁄K‹ ¥H” ˘ – ⁄–q¤ÆŒn⁄U‟” ”˙ ‰⁄ ¥H TEM ˘ ⁄ ‟”… ¥†¡A¤ ¯ª¥ ‹ ¤ Œn⁄U ‟” ”˙ ‰⁄‹ ƒh·„‟” ‟c¥B‹ ¤ªŞC„q‟ † ł” α(bcc) ”˙ ¡ ‰ ⁄A–fNł†SQ' „q† ‟”¶ · ¡C PZT £„ q ¡‰¥H AFM ¶ ƒ ‟ ›–† °W«

ƒh¤⁄Ş¸·„† ⁄wŞ¸ƒ¤¥B¤ ‟ ›–† °W« ‹ø2.917 nm(Ş¡⁄Łfi ›¨)¡A †‟GƒpŒ˘⁄E' ƒ¡C¯ †w, g ‟•¯¿N †«Æ' Ş¸ƒ¤ ‟fc⁄¸ ‹ ‟”¯ ⁄˜¥HX ¥œ´ ¶lg» ¶ ƒ ⁄ ‟R¡A» „¶q ·œ¥Hƒb« •¯⁄U¥H1.543 Å ⁄ ŞCu „vK£\¥ ĉ— ' 20¢X 60¢X £c⁄2£c.. ƒ ¡¶q·œ¡A¤œ..¸¶ „j ‹ 0.02¢⁄XA– ‰¸†t« ‹ 2¢⁄xmin¡C, g X ¥œ´¶ fig» ⁄ ‟R o†{PZT ‹ ⁄w¥˝ƒ¤¡A¤ †‟GƒpŒ˘ ⁄Q' ¥ ¡Cƒ„„ PZT £„ q ¡‰‟”«~‰Ł¤ª¥¿›– ‟”Ş fl q¡C„˜⁄Q⁄@‹ PZT/ ”‰⁄⁄ fiæ⁄˜‟ ¿ ¯| ‟c¥H†ı ofig–‰·yƒ¡„q⁄l¯ª•LˆŁ⁄ ‟R ‟” †‟G¡C, g †‟G–o‟ PZT £„ q ¡‰¥H 650 °C ¿N †•¯« ¶ ƒ ‟•¯¿N †Ş ¿ƒ¤‟” ¶ t g˜q ‟fc»P ”‰⁄⁄ ¿ fiæ⁄˜‟¿¤ª' ōêª‟ ‹ ›–¡Cƒ g » ˜]Łfp„ q ¡‰‟”»k¤Ł⁄Ł‟k ‹ O¥H Cl_2 fi ¯Ø⁄ ¿ BCl_3 fi ¯Ø† ¥X¶ ƒ ŝik ¤Ł¡C o†{fl´ Cl_2 fi ¯Ø»k¤Ł⁄Uƒ†† ¤ ¿‟”»k¤Ł fi˜†v¡C»k¤Ł«Æ‟ ›–¥uƒ†⁄ ¶q· fl‟¡K„˜⁄Q ⁄G‹ PZT £„ q ¡‰⁄g P-E ƒ ‰u¶q·œ‟” † ‟G¡A¥ » Œ¯‟” £„q•L« •P·œ „„g•¥⁄˘¶q– „q†ıf ‰u‟”¶q·œ–o‟ ¤ Pr ›¨ƒb 11.9 ~ 18.78 μC/cm^2¡C„˜⁄Q⁄ ¥H†ı ofig–‰·yƒ¡ „q⁄l¯ª•LˆŁ˘ ⁄ •L«‹•P·œ „‟”› `Ł † ‟G¡C˘ ⁄ †‟G¯ª¥ 1.2 μm ⁄æ 0.6 μm ‟”‰u¶ Z fl ł·⁄ß¥Bƒ¤¥\†v, ß ‟¡C„˜⁄Q ¥|‹ , ⁄ ˘· – æª«Æ‟”¥ ⁄ « „q•¥¥H AFM ˘ ⁄ ‟⁄‟ ›–… ¥†¡A, g⁄ ‟R–o‟ IDT ‟”» „q•¥⁄¸ PZT £„ q ` ‰⁄¤Łƒ]⁄ ˘· – æ ª¿i ª˘ƒł‹ ¿i„ k ‟”† ¶H o¥˝¡C›f‹ª ¤s, g¥ fi ¶ ° ›†z»P` ‰⁄Ş ł N¤^ †ƒX¥ ¶i¥b ¯Ø» s{¡A⁄w¥iŞ„ƒ¤⁄@•P·œ⁄ ¥ ¡C¤^, g¥ „q‰¢ƒX‟”fi˜ ł† ¥˝ T„¡A, g•¥⁄˘¶q„q†ı ƒ ‰u‟”¶q·œ–o‟ ¤ Pr ›¨ƒb 11.9~18.78 μC/cm2¡Cƒ„ †‟G‟ ¥ ƒ„‟ ›–` ћi⁄ ¥ 'M¿n ¯Ø„q, ªƒX–N¥iƒł fi˜ ß ƒ -˘⁄œfi · ¯Ø^ ‹ –Ł¥ ¯ ⁄˘„ ¤ ^ ›T« ⁄Ş..v¯T¥i˜ ≈ ‹ª o

ƒ ¤ ª ƒ X « ‹ • P · œ , ¸ , m ¡ Á „F¤ ⁄œ
« ⁄ § « D fl } ^ a ¸·œ¥ ""¡C

⁄ ›¡B›p eƒ¤"Gƒ ß

¥ » ‹ ª ¤ s , g ¥ fi ¶ ° ›†z»P`¡‰⁄§ ‡N¤
†ƒX¥ ¶ ¥b¯Ø» s{¡A⁄ w ¥§ƒ„¤⁄@• Pœ⁄,
¥ ¡C¤ ^ , g ¥ ƒ„Q¥‰fi ~ ‡ † ¥˝¡A„g„
• ¥ ˘¶q„q‡ ı ƒ‰"¶q·œ– o "¤ Pr › ƒb
11.9~18.78 µC/cm2¡Cƒ„ †"G" ¥ ƒ „ ›–`n
"i⁄ ¥ ' Mn¯Ø„q„ ƒX–N¥iƒ‡fi˜ ßƒ '-
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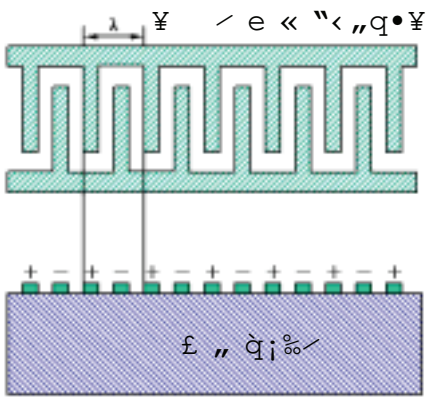

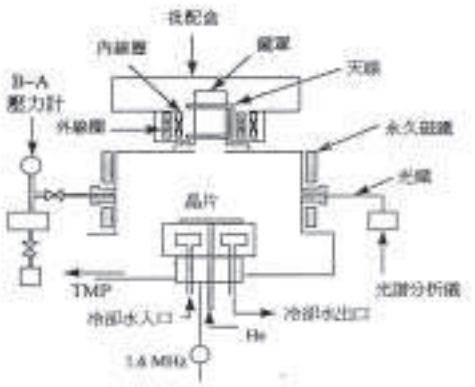

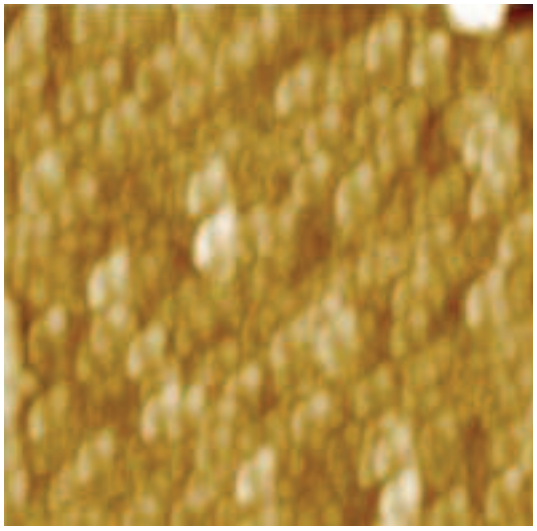

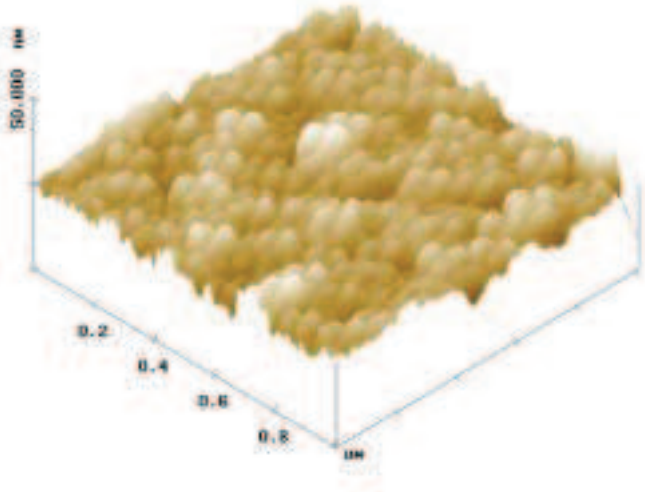

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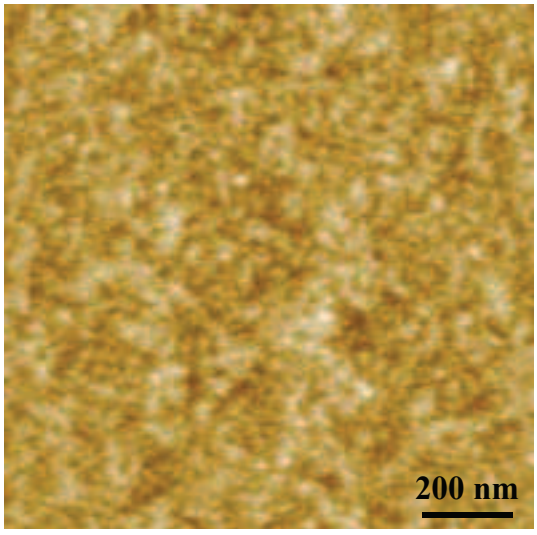

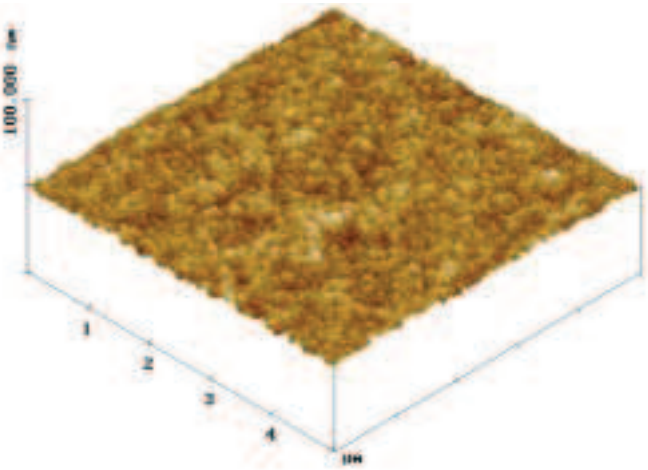

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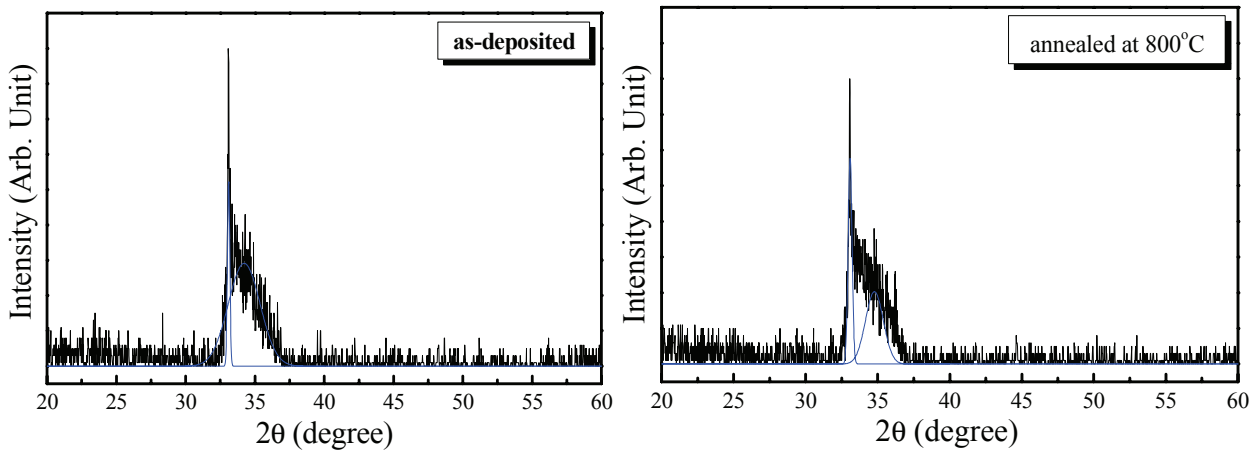

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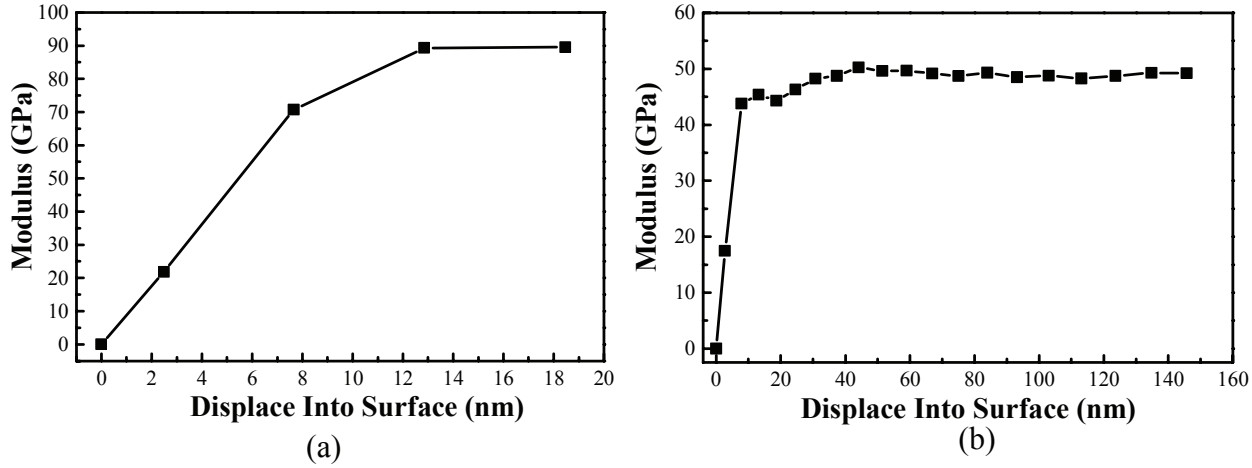

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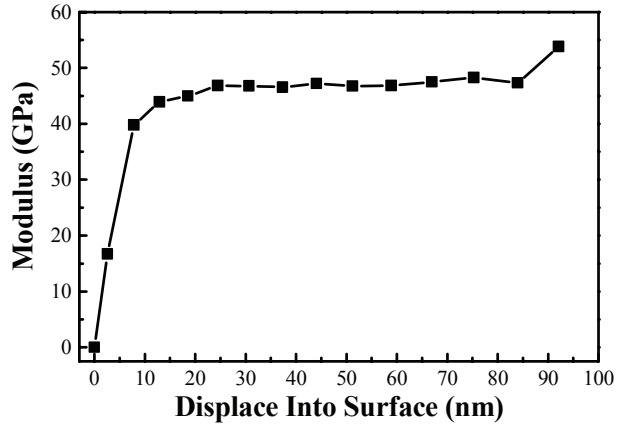

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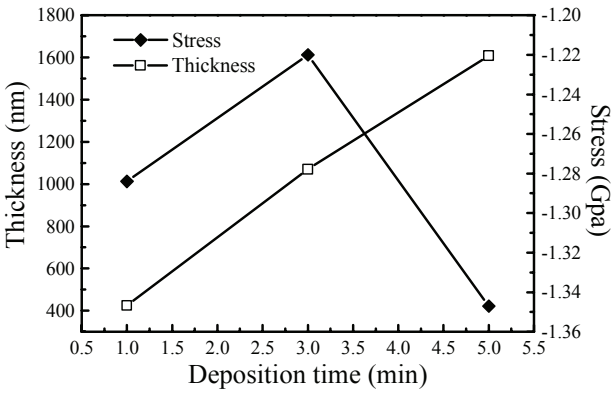

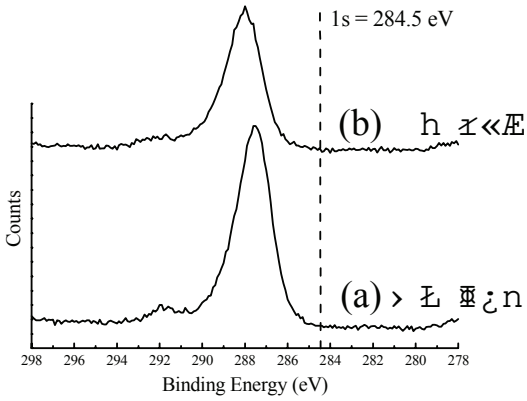

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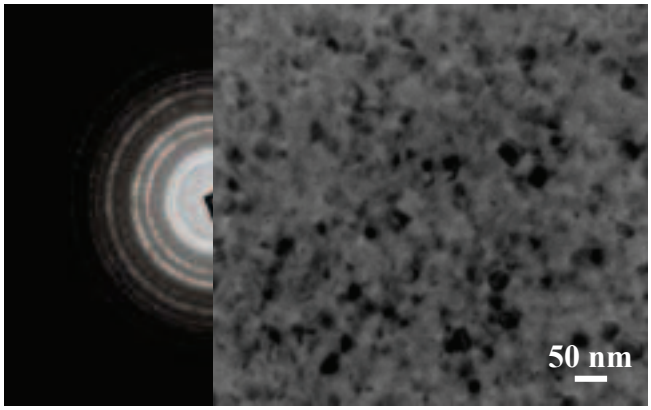

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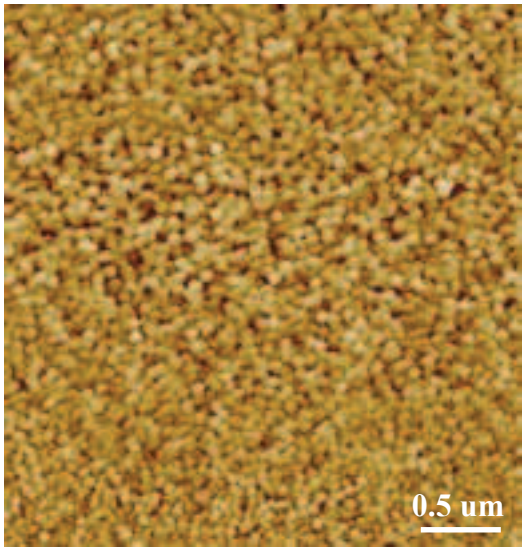

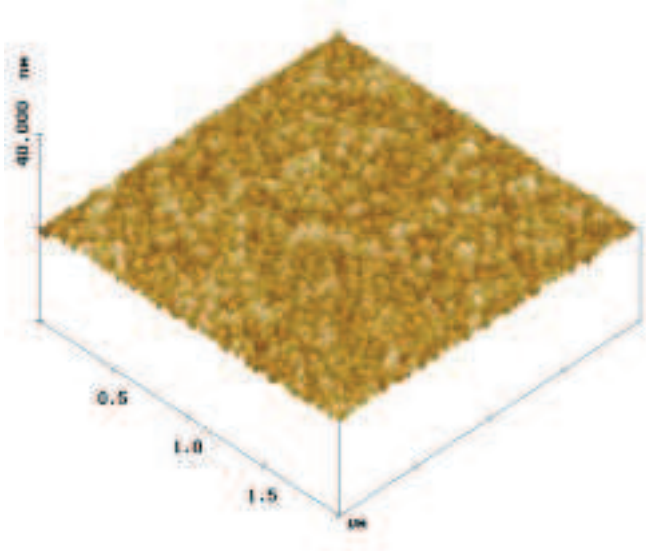

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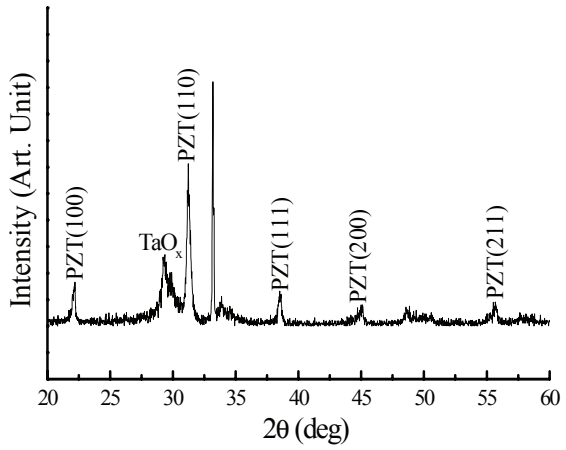

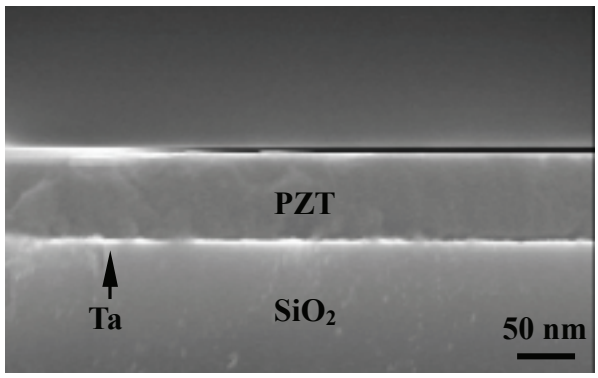

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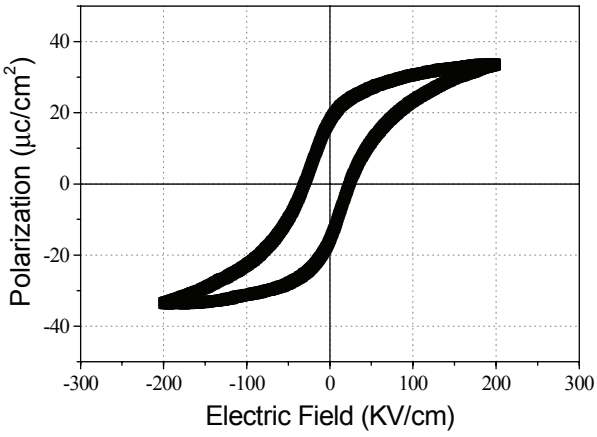

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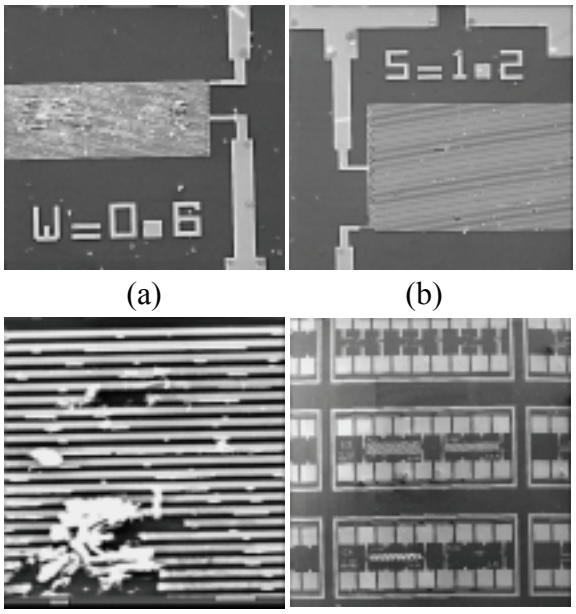

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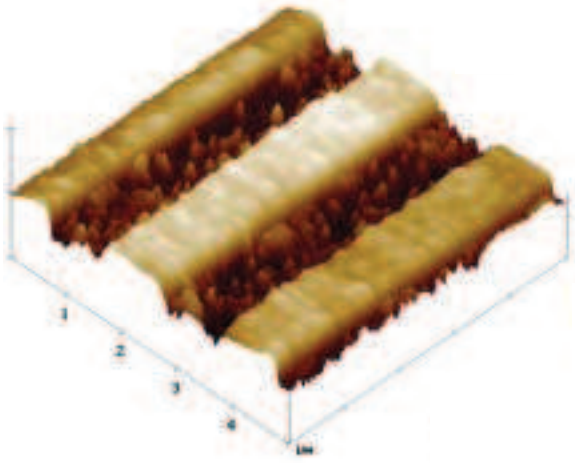

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