Effect of annealing conditions on the microstructure of SBT Capacitor for NVFRAM

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Abstract : Ferroelectric $SrBi_2Ta_2O_9$(SBT) ceramics were deposite on Pt/Ti/SiO2/Si substrates using a sintered SBT target and then were annealed in the oxygen atmosphere at 750℃, the most excellent characteristics were shown, and the remnant polarization ($2P_r$) value and the coercive electric field (E_c) were respectively about 12.40[μC/㎠] and 30[kV/cm]. Moreover, the excellent fatigue characteristic t was little aged even after 10^{10} cycles of switchings. The leakage current density and the dielectric constant of the SBT capacitor annealed in the oxygen atmosphere were respectively approximately 2.13×10^{-9} [A/㎠] and 340.

Key Words : $SrBi_2Ta_2O_9$(SBT) ceramics, remnant polarization, dielectric constant, leakage current density

1. INTRODUCTION

The SBT thin film is mainly formed by coating as substrate with a solution of 2-ethylhexanatesolution, which is a carboxylate, followed by heat treatment of coating a substrate.[1] The SBT film has so far been heat treated at temperatures as high as 800℃ for 1 hour in oxygen atmosphere, which is more than 100℃ higher than the 65 0℃ at which PZT is heat treated.[2] Therefore lowering of the heat-treatment temperature for the SBT film is desired. Recently, some workers tried low-temperature formation of SBT films.[3] SBT thin films are knows to have a superior endurance property and a small coercive field after crystallization at high temperatures around 700-800℃.

Here, we report effect of annealing conditions on the microstructure of SBT Capacitor for NVFRAM using RF magnetron sputtering technique.

2. EXPERIMENTAL

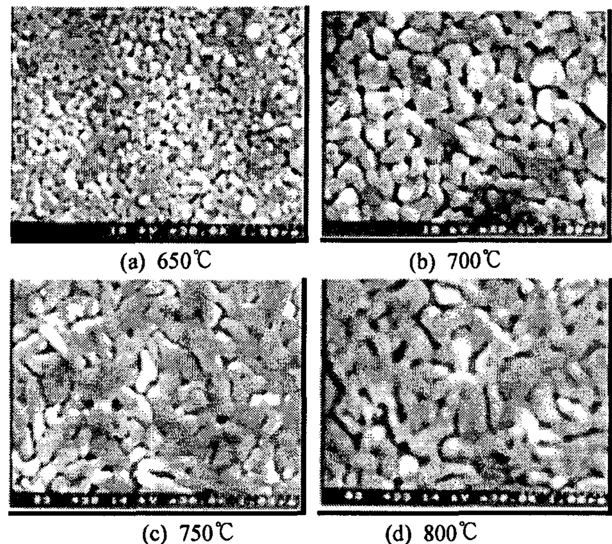
Table 1. Sputtering condition of SBT thin films.

sputtering condition	values
target	SBT(2 inch)
substrate	p-type $Pt/TiO_2/SiO_2/Si(100)$
base pressure	5×10^{-6}[Torr]
working pressure	2×10^{-2}[Torr]
RF power	100[W]
annealing temperature	650-800℃
Ar : O_2	1 : 1
annealing time	30[min]

The detailed sputtering conditions of SBT thin films are summarized in Table1.

3. RESULTS AND DISCUSSIONS

In order to observe the structure and surface of the crystal grain, the x-ray diffraction pattern of the SBT thin film as deposited at 400℃ and then annealed at 600℃ ~ 850℃ was shown in Fig. 1.



(a) 650℃ (b) 700℃ (c) 750℃ (d) 800℃

Photo 1. SEM micrographs of SBT capacitor with annealing temperatures

Photo 1 showed the micro structure of the SBT thin film surface depending upon various annealing temperatures in the oxygen atmosphere.

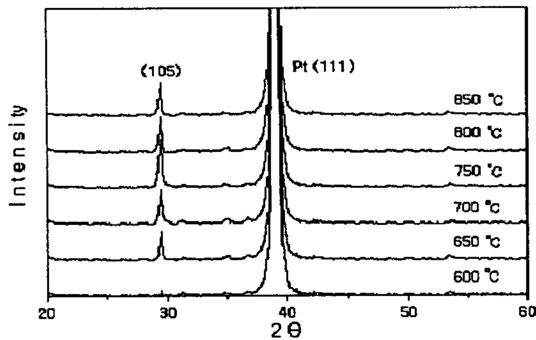


Fig.1. X-ray patterns of SBT thin films with annealing temperatures

Fig. 2 showed the polarization hysteresis curve depending upon the annealing temperature in the oxygen atmosphere.

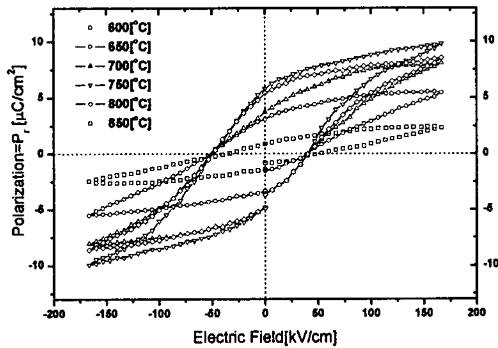


Fig. 2. P-E hysteresis loop of SBT capacitors with annealing temperature in oxygen atmosphere

Fig. 3showed the fatigue characteristic when 5V was applied to the specimen annealed at various temperatures in the oxygen atmosphere.

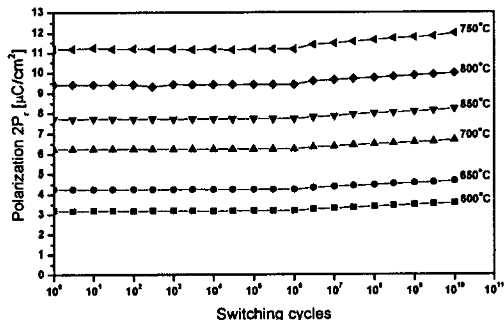


Fig. 3. Fatigue characteristics of SBT capacitors with annealing temperatures in oxygen atmosphere

A change in the dielectric constant depending upon the annealing temperature was shown in Fig. 4.

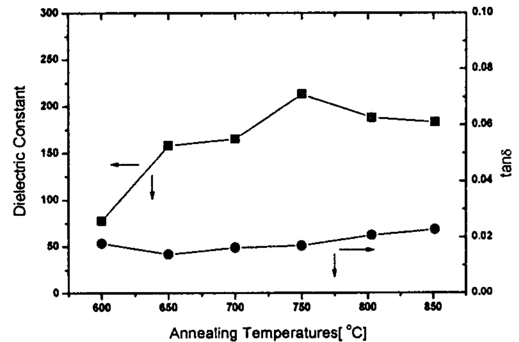


Fig. 4. Variations of dielectric constant with annealing tempereature

4. CONCLUTIONS

It could be observed in the SBT thin film annealed in the oxygen atmosphere that the completest crystallization was accomplished around 750℃ and grains grew in the rod-like.

The most excellent characteristics were shown, and the remnant polarization ($2P_r$) value and the coercive electric field (E_c) were respectively about 12.40[μC/㎠] and 30[kV/cm], The leakage current density and the dielectric constant of the SBT capacitor annealed in the oxygen atmosphere were respectively approximately 2.13×10^{-9} [A/㎠] and 340..

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