Effects on Magnetic and Electric Properties by Cation Substitution (Mg, Co) in Multiferroic $Ga_{0.6}Fe_{1.4}O_3$ thin films

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1. 서론

Magnetoelectric (ME) property has become an growing issue because of multifunctional or multibit device application. Among of ME materials, $(Ga,Fe)_2O_3$ (GFO) is the candidate material because of high magnetic T_C as 370 K at Fe=1.4 and non-zero remnant magnetization. However, GFO has serious issue about ferroelectricity that should be solved for new room temparature multiferroic. Ferroelectric polarization of GFO have not been reported yet due to high level charge conduction. Recently, we have solved the issue by substituting Mg [1]. However we cannot be sure the conservation of magnetic property such as high T_C. Thus we have tried different element as Co that is magnetic one.

2. 실험방법

Co doped GFO (GFO:Co) thin films were deposited by pulsed laser deposition method with different Co concentration at 750℃ with oxygen gas as 200 mTorr on $SrRuO_3/SrTiO_3$(111) and Pt/Ti/YSZ(111) substrates. Composition of the GFO:Co was obtained by energy dispersive spectrometer with scanning electron microscopy. Their crystallization was studied using x-ray diffraction patterns. Charge conduction behavior was characterized by HP 4145B semiconductor parameter analyzer equipped with probe station. M(T) and M(H) curves were obtained by SQUID measurement to study magnetic properties of the GFO:Co thin films. Scanning probe microscopy was employed to show their surface morphology and charged state. Especially, piezoresponce force microscopy (PFM) was used when we obtained local ferroelectricity.

3. 실험결과

The GFO:Co thin films were epitaxially grown along b axis shown in Fig. 1. Charge conduction was reduced with increasing Co concentration until the GFO:Co 1.34%. The magnetic T_C was also reduced and M(H) curves showed ferrimagnetic shape. We could obtain ferroelectric polarization using PFM.

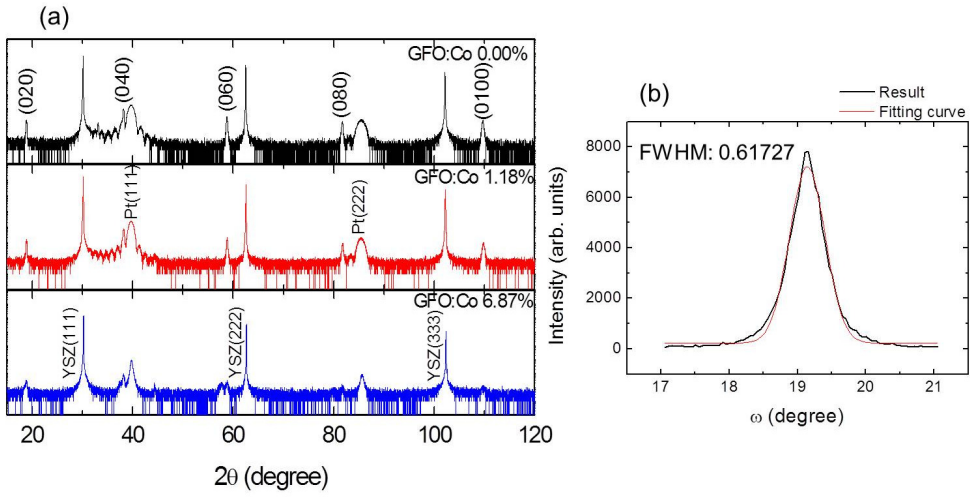

Figure 1. (a) X-ray diffraction patterns for the GFO:Co thin films on Pt/Ti/YSZ(111) to characterize their crystalline structure. (b) Rocking curve for the GFO:Co 1.18% thin films

4. 고찰

In the GFO:Co showed the lowest charge conduction charge conduction, magnetic T_C was the lowest as 355 and 332℃ depending on substrates and bottom electrodes that is still above room temperature by SQUID measurement because Fe ions were substituted by Co ion. The mechanism of ferroelectric polarization of the GFO:Co is charge density modulation without dipole of a cation and anion pair[2]. When there is non-centrosymmetric charge distribution, polarization can be generated only with cations. In the GFO:Co thin films, Co_2+ and Fe_3+ induced ferroelectric polarization.

5. 결론

GFO:Co showed ferrimagnetic M(H) by SQUID and ferroelectric P(E) behaviors by piezoresponce force microscopy owing to charge density modulation. Therefore, we suggest the optimal Co concentration in GFO thin films for a new room temperature multiferroic material.

6. 참고문헌

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