KTaO3 Thin Film의 Semiconducting 합성

*구자일, *엄우용, *안창환, **배형진

*인하전문대학 디지털전자정보과, **[1]Department of Materials Science and Engineering, University of Florida, Gainesville FL 32603, USA

drku@inhatc.ac.kr

Synthesis of Semiconducting $KTaO_3$ Thin films

*Ja-yl koo, *Woo-yong ohm, *Chang-Hwan Ahn, **Hyung-Jin Bae

*Department of Digital Electronics Information, Inha technical College, **[1]Department of Materials Science and Engineering, University of Florida, Gainesville FL 32603, USA

Abstract

In this study, the synthesis and semiconducting properties of cation and defect-doped KTaO3 film is reported. KTaO3is an important material for optoelectronic and tunable microwave applications. It is an incipient ferroelectric with a cubic structure that becomes ferroelectric when doped with Nb. the films were grown on (001) MgO single crystal substrates using pulsed-laser deposition. Semiconducting behavior is achieved by inducing oxygen vacancies in the KTaO3 lattice via growth in a hydrogen atmosphere. The resistivity of semiconducting KTaO3:Ca films was as low as 10cm, and n-type semiconducting behavior was indicated. Hall mobility and carrier concentration were 0.27 cm2/Vs and 3.21018cm-3,

1.ResultsandDiscussion

Initial efforts focused on the growth of epitaxial Ca doped KTaO3in an oxygen background ambient. Both crystallinity and transport were studied as a function of deposition temperature and oxygen pressure. Figure 2 shows the X-ray diffraction results for KTaO3:Ca films grown in 10-4 Torr of oxygen at various deposition temperatures. For the 50/50 Ca doped-KTaO3/KNO3 segmented target configuration, a deposition temperature of 700 oC resulted in a high degree of crystallinity as determined by X-ray diffraction. The lack of good crystallinity for KTaO3:Ca films deposited at 750 oC may reflect potassium deficiency due to the high vapor pressure of potassium at this deposition temperature. Despite the inclusion of Ca as a donor impurity, the films deposited at 10-4 Torr were insulating and transparent with no measurable conductance.

In order to explore the doping behavior further, Ca doped films were grown at 700 oC in an oxygen ambient ranging from vacuum (5 x 10-6 Torr) to 10-1 Torr of oxygen. Figure 3 shows the X-ray diffraction results for KTaO3:Ca films grown on MgO substrate as a function of oxygen pressure at a deposition temperature of 700 oC. Over this entire pressure range, the epitaxial growth of Ca-doped KTaO3 was achieved. Note that the strongest intensity (0 0 1) KTaO3 peaks were observed for an oxygen pressure of 10-3 Torr. However, for the entire pressure range, the Ca-doped KTaO3 films were insulating. This result differs from that observed for other perovskites, such as the titanates, in which semiconducting behavior is observed for growth in vacuum.

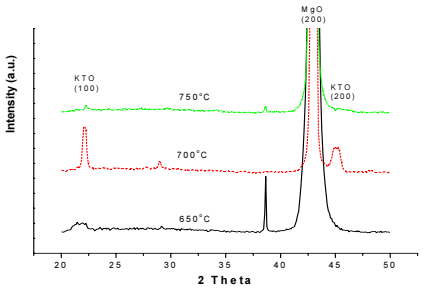

Figure 1. X-ray diffraction results of KTaO3:Ca film grown on MgO (100) substrate as a function of deposition temperatur

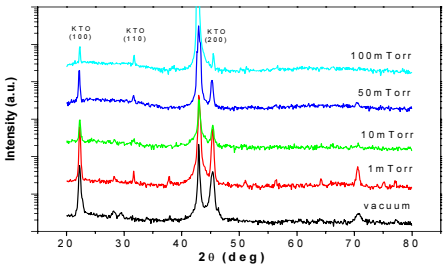

Figure 2. X-ray diffraction results of KTaO3:Ca film grown on MgO (100) substrate as a function of different oxygen pressure at deposition temperature of 700 oC.

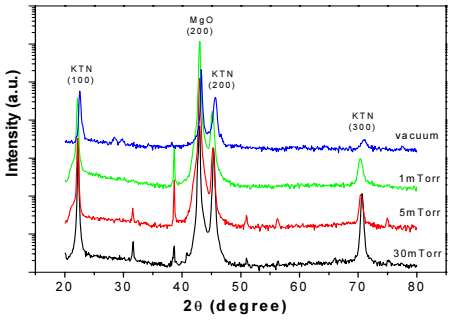

Figure 3. X-ray diffraction results of Ca doped KTaO3 semiconducting film grown on MgO (100) substrate at deposition temperature of 700 ^{o}C in reduced pressure of 96% Ar/4% H2

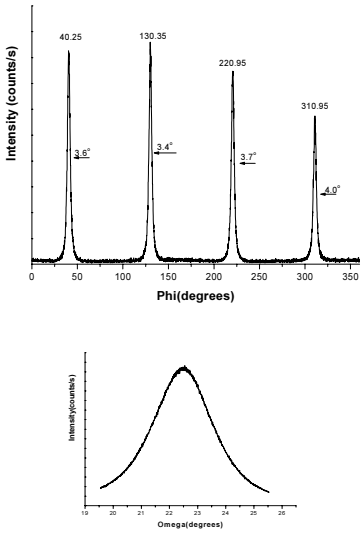

Figure 4. (a) X-ray diffraction Phi scan and rocking curve data.

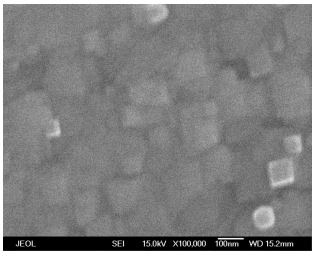

Figure 5. FE-SEM images of surface morphology of semiconducting KTO:Ca film on (100) MgO substrate, which was deposited at 700C for 1hr with 30mTorr of 96%Ar/4% H2 mixture gas using pulsed laser depositio

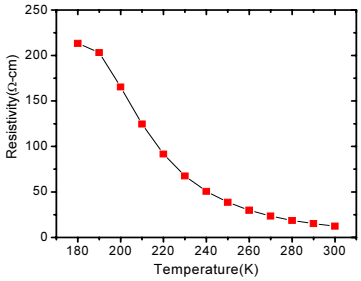

Figure 6. Resistivity of Ca doped KTaO3 thin film as a function of temperature.

3. Conclusion

In this study, conditions for growth of insulating and semiconducting KTaO3:Ca film were investigated. Unlike other perovskites, such as the titanates, semiconducting behavior is not observed for growth in vacuum. This resistance to forming free carriers reflects the tendency for K and Ta to assume a specific valence state. The difficulty in varying the valence state of the cation greatly retards the ability to make the films semiconducting. Nevertheless, epitaxially grown KTaO3:Ca films grown in 30 mTorr partial pressure of 96% Ar/ 4% H2 atmosphere at 700 oC were semiconducting. The resistivity of KTaO3:Ca film was 10.4 cm at room temperature and showed n-type semiconducting behavior.

References

1 Lemee N, Dubourdieu C, Delabouglise G, Senateur JP, and Laroudie F, "Semiconductive Nb-doped BaTiO3films grown by pulsed injection metalorganic chemical vapor deposition," Journal of Crystal Growth 2002; 235: 347-351.