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Research Article

GENERIC ANALYSIS AND MORPHOLOGICAL STUDY OF TEXTURED MGO FILMS BY THE SPRAY PYROLYSIS TECHNIQUE AS BUFFER LAYERS FOR COATED CONDUCTORS

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ABSTRACT
The prospect of using squirt pyrolysis as a uncomplicated, chemical, low cost process for the manufacturing of MgO slim films is broadly used as buffer layers intended for second generation encrusted conductors is studied. MgO films were created on Si (100) single crystal substrates and diverse exterior morphologies were pragmatic at diverse deposition temperatures. C-axis textured MgO films with soft morphologies were deposited on Si (100) single crystal. Rocking curves exposed an exceptional out of plane texture with a FWHM between 0.950 and 1.010. As the general deposition time was improved from 32 min to 64 min, the width and the rms coarseness of the produced film was just about doubled demonstrating that a good organization over the procedure was established.

Keywords: *MGO Films, Spray Pyrolysis*

INTRODUCTION
The squirt pyrolysis system presents plentiful recompense such as ease, low cost, non toxic precursors, good reproducibility, and no need for vacuum; it has been therefore used over the years for the production of slim films of simple oxides, mixed oxides, metallic spinel type oxides, and chalcogenides films (Patil, 1999). MgO thin films have been extensively used as a chemically steady buffer layer for the deposition of high Tc superconducting films and perovskite-type ferroelectric films because of its good lattice matching with mentioned materials and low chemical reactivity. Many ferroelectric and superconducting oxide films, such as PZT, LiNbO3, BaTiO3 and YBa2Cu3O7 have been organized on Si substrates using MgO as a middle layer (Fork *et al.,* 1991; Desisto & Henry, 1991; Kim *et al.,* 1996; Senzaki & Mitsunaga, 1996; Yoon *et al.,* 1996). Additionally, MgO has there compense of a wide band gap, low optical loss, and a relatively low refractive index that permits confined optical modes in ferroelectric materials. Lately, MgO thin films have also been functional as shielding layers of dielectrics to improve the discharge quality and the panel's life span in an ac-plasma display panel (ac-PDP) (Kim *et al.,* 2000). A number of methods for the preparation of MgO films and coatings have been developed all through the last few years, such as pulsed laser deposition (PLD), magnetron sputtering, electron beam evaporation, metal organic chemical vapour deposition (MOCVD), and spray pyrolysis (Ishiguro *et al.,* 1996; Shih *et al.,* 1991; Talacchio *et al.,* 1989; Lu *et al.,* 1993; Yi *et al.,* 1996). Ultrasonic spray pyrolysis has recently emerged as a variable deposition process capable of developing high quality oxide and sulphide slim films. The Ultrasonic spray pyrolysis technique is based on the thermal decomposition of the source solution sprayed by an ultrasonic nozzle onto the heated substrate surface. Compared with other deposition Strategies, the ultrasonic spray pyrolysis technique possesses the benefit of simplicity, low equipment cost, high deposition rate and good thickness evenness over a large area. In this study, high quality MgO thin films have been successfully deposited by the ultrasonic spray pyrolysis, and the characteristics of obtained MgO films were studied by XRD, SEM and SRM. The growth mechanisms of MgO films deposited at different temperature were discussed. The main focus in this paper will be to produce MgO thin films, widely used as buffer layers in the coated conductor architectures.
One of the problems for the commercialisation of the coated conductors is the high cost related to the expensive physical methods employed for the fabrication of the YBCO superconducting material and the essential buffer layers (Malozemoff *et al.,* 2000). Recently low cost chemical routes such as MOD have been employed to substitute the complex physical methods (Rupick *et al.,* 2004; Paranthaman *et al.,*

2006). Despite spray pyrolysis being one of the most well known low cost chemical deposition method for thin films, it has not been widely used for the production of either the superconducting layers or the buffer layers for coated conductor architectures. There are few reports referring to the production of YBCO films by the aforementioned method (Supard *et al.*, 2003; Ferreri *et al.*, 2001). Previously, (Shields *et al.*, 2002) has reported the production of YBCO films on STO (100) single crystal substrates (Shields & Kawano *et al.*, 2002). The precursor solutions have been prepared by dissolving Y2O3 BaCO3 and CuO in a mixture of nitric acid and distilled water. Good epitaxial films were produced with a Jc of around 1.9 *105 A cm-2 (77K, 0 Tesla). Furthermore, YBCO has been deposited on buffered Ni using the same spray parameters identified for the successful deposition of YBCO on STO single crystals (Shields *et al.*, 2002). MgO thin films have been widely used as buffer or template layers for YBCO coated conductor architectures (Paranthaman *et al.*, 2005; Groves *et al.*, 2001). MgO has been deposited on various substrates by spray pyrolysis but once again the texture of the obtained films is not the main focus of these studies (Bian *et al.*, 2004; Kim *et al.*, 2000; Fu *et al.*, 1999; Stryckmans *et al.*, 1999).

MATERIALS AND METHODS

The experimental set up has been described by Pavlopoulos, 2007 briefly; the atomization of the initial chemical solution was achieved with the help of a commercial ultrasonic nebuliser. The substrate was attached to a stainless steel holder, which was positioned in the middle of the cylindrical furnace (height 30 cm, diameter 15 cm). Argon gas was used to transport the mist produced in the nebuliser onto the substrate. During spraying the temperature of the substrate was observed to drop 5-70C for each 15 sec spray. After 15 sec, therefore, the gas flow was turned off for 1 min and 45 sec and the substrate was allowed to stabilize to its set temperature. The solutions were prepared by dissolving an appropriate amount of Mg $(NO_3)_2$. $6H_2O$ in 100 ml of distilled water for the production of MgO thin. The structural properties of the films were studied by the XRD technique and rocking curves with the aid of X Ray Diffractometer. Surface morphology and fracture cross section thickness were examined by SEM and surface roughness by contact mode AFM.

Preparation of MgO Thin Films

In this section we will concentrate on the efforts to produce biaxially textured MgO thin films by depositing them on Si (100) single crystal substrates. In this case the lattice mismatch is 28.8 % but if the MgO unit cell rotates by 45° the lattice mismatch is equal to 9.7 %.

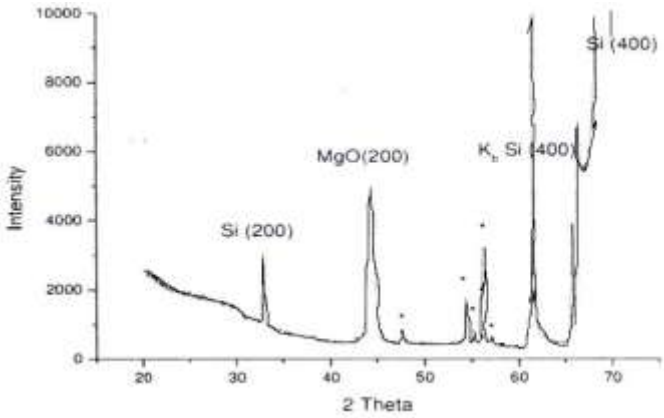

Figure 1: XRD pattern of the MgO film deposited on Si (100) at 650°C from a0.078 M solution

Figure 1 illustrates the XRD pattern obtained from the film deposited at 670°C from a 0.078 M solution- the deposition time was set to 64 min and the flow rate was fixed to 1.0l/min. The films are c-axis oriented since only the peaks from the Si substrate and the MgO (200) plane are detected. The peaks noted as * can be attributed to high order reflections from the substrate. The rocking curve of the (200)

peak of the deposited film shows a FWHM equal to 0.950 indicating that the produced filmpresented an excellent out of plane texture (Figure 2).

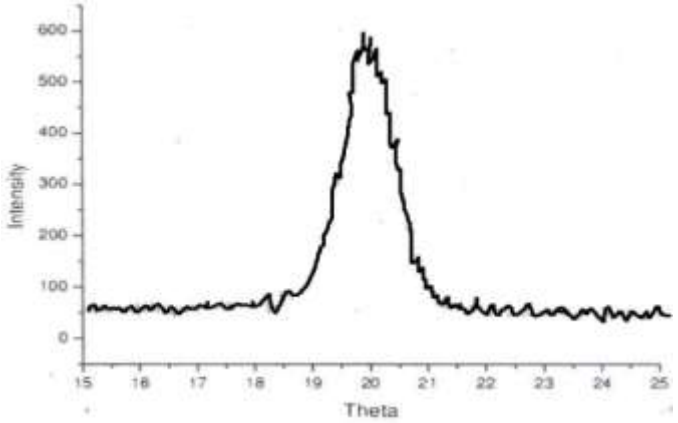

Figure 2: Rocking curve of the MgO (200) peak of the MgO film deposited on Si (100) at 670°C from a 0.078 M solution

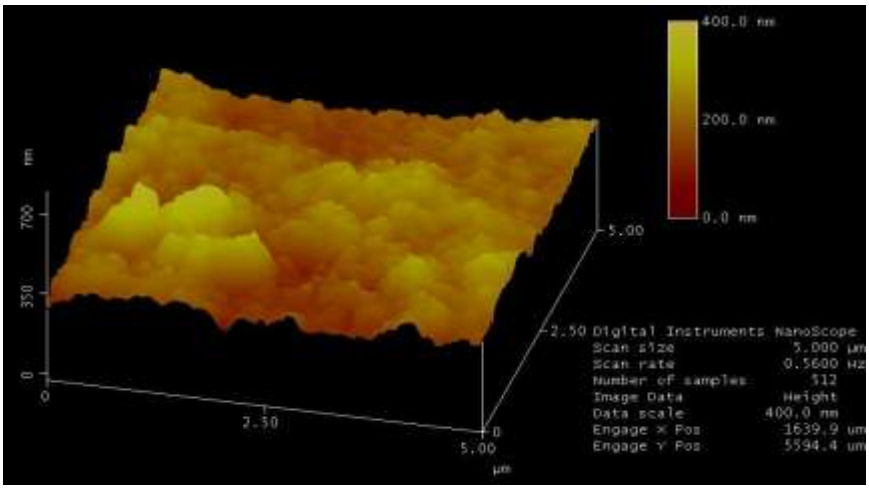

Figure 3: 3-D 5*5 □ m2 AFM picture of the MgO film deposited on Si (100) at 670°C from a 0.078 M solution with a deposition time equal to 64 min

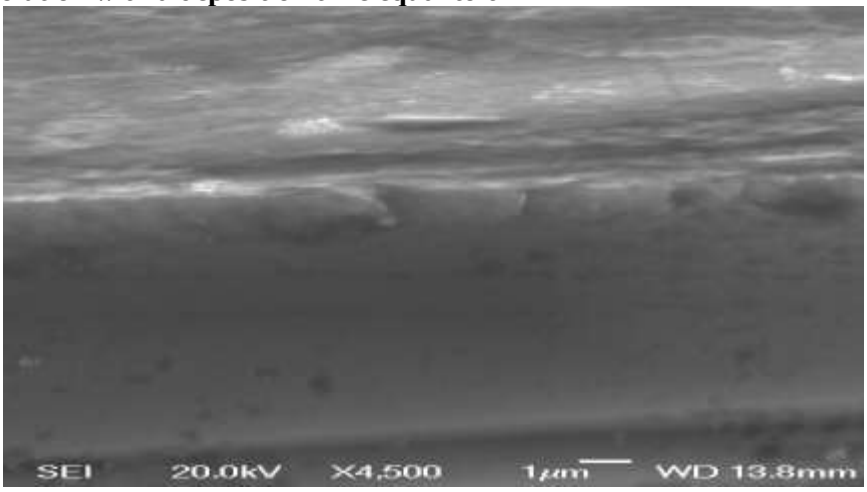

Figure 4: SEM picture of the fracture cross section of the MgO film deposited on Si (100) at 670°C from a 0.078 M solution with a deposition time equal to 64 min

The rms roughness calculated from the 3-D 5*5 µm2 AFM picture is 43.3 nm (Figure 3). SEM studies of the cross section of the fractured surface (Figure 4) illustrate a dense and homogeneous MgO layer with film thickness estimated between 1650 to 1750 nm.

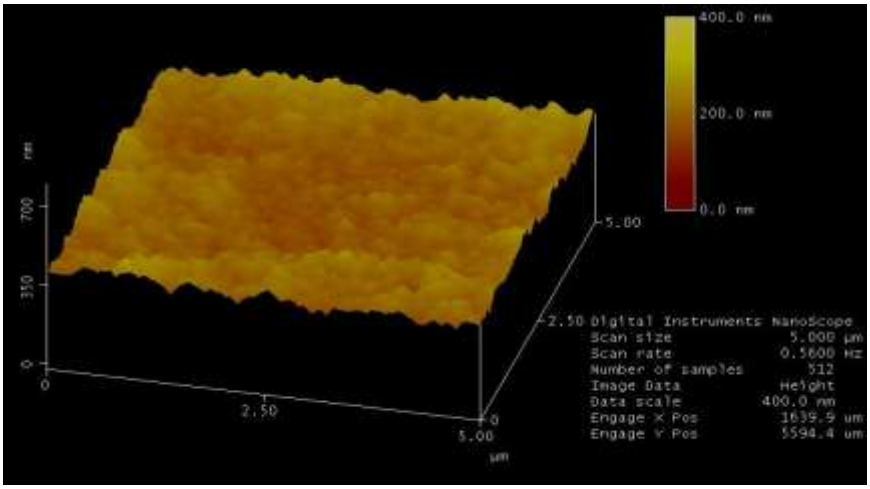

Figure 5: 3-D 5*5 µm2 AFM image of the MgO film deposited on Si (100) at 650°C from a 0.078 M solution with a deposition time equal to 32 min

Films with reduced thickness were obtained when the deposition time was reduced to 32 min temperature; solution concentration and flow rate were kept constant. The thickness of the film is between 650 to 750 nm. The produced film is once more c-axis textured as identified from the XRD pattern. The FWHM as calculated from the rocking curve is 1.01°. The rms roughness as calculated from the 3D AFM picture in a 5*5 μm^2 area is 22.6 nm (Figure 5).Figure 11: 3-D 5*5 µm2 AFM image of the MgO film deposited on Si (100) at 650°C from a 0.078 M solution with a deposition time equal to 32 min.

CONCLUSION

C-axis textured MgO (200) films with various deposition times were obtained on Si (100) single crystal. The typical characteristics of island growth and layer growth mechanism were observed at deposition temperatures of 650 and 680 ^{O}C, respectively. As the overall deposition time was increased from 32 min to 64 min, the thickness and the rms roughness of the produced film was approximately doubled indicating that a good control over the process was acquired. All the films exhibited an excellent out of plane texture with a FWHM varying from 0.950 to 1.010.The dependence of film microstructure and micrograph on substrate temperature can be explained in terms of deposition modes and growth mechanism. High quality MgO thin films may be obtained through the control of deposition modes and growth mechanism for the spray pyrolysis method. Results show that our MgO films deposited at the optimal condition (670 ^{O}C) have much better quality than those in previous spray pyrolysis research. The MgO thin films with this quality should be suitable as a buffer layer for the subsequent growth of oriented ferroelectric materials.

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REFERENCES

Robinson Kelly S, Turnbull Robert J and Kim Kyekyoon (1980). Electrostatic Spraying of Liquid Insulators. *IEEE Transactions on Industry Applications* **IA-16(**2) 308-317

doi: 10.1109/TIA.1980.4503787
Atsushi Masuda, Yasuhiro Yamanaka, Mitsutoshi Tazoe, Takanori Nakamura, Akiharu Morimoto, Tatsuo Shimizu (1996). Preparation and crystallographic characterizations of highly oriented Pb(Zr0.52Ti0.48)O3 films and MgO buffer layers on (100)GaAs and (100)Si by pulsed laser ablation. *Journal of Crystal Growth* **158**(1–2) 84-88.
Van Zomeren A.A., E.M. Kelder, J.C.M. Marijnissen, J. Schoonman (1994). The production of thin films of LiMn2O4 by electrospraying. *Journal of Aerosol Science* **25**(6) 1229-1235.
Kwak BS, Boyd EP, Zhang K, Erbil A and Wilkins B (1989). Metal organic chemical vapour deposition of [100] textured MgO thin films. *Applied Physics Letters* **54** 2542.
Ji Ming Bian, Xiao Min Li, Tong Lai Chen, Xiang Dong Gao, Wei Dong Yu (2004). Preparation of high quality MgO thin films by ultrasonic spray pyrolysis *Applied Surface Science* 297-301 Volume 228, Issues 1–4, (30 April 2004)
Chen C, Kelder EM, Van der Put PJJM, Schoonman J (1996). Deposition of MgO thin films by modified electrostatic spray pyrolysis method. *Journal of Material Chemistry* **6** 765-771.
Choon Kun Ryu and Kyekyoon Kim (1995). Fabrication of ZnO thin films using charged liquid cluster beam technique *Applied Physics Letters* **67** 3337 http://dx.doi.org/10.1063/1.115239
Pavlopoulos D (2007). Effort to produce textured CeO2 and MgO films by the spray pyrolysis technique as buffer layers for coated conductors. *Thesis* University of Birmingham.
D. K. Fork, F. A. Ponce, J. C. Tramontana, N. Newman, Julia M. Phillips and T. H. Geballe (1991). High critical current densities in epitaxial YBa2Cu3O7−δ thin films on silicon-on-sapphire *Applied Physics Letters* 58, 2432. doi: http://dx.doi.org/10.1063/1.104864
Ferreri A, Nelstrop JAG, Caplin AD and Mac Manus-Driscoll JL (2001). Microstructure and superconducting properties of ultrasonically spray pyrolysed YBa2Cu3O7−x films. *Physica C* 58-61 Volume 351, Issue 1, (1 March 2001)
Xiaorong Fu, Guangming Wu, Shigeng Song, Zhitang Song, Xinzhong Duo, Chenglu Lin (1999). Preparation and characterization of MgO thin films by a simple nebulized spray pyrolysis technique Applied Surface Science 223-228 Volume 148, Issues 3–4, (July 1999
Groves JR, Arendt PN, Foltun SR, Jia QX, Holesinger TG, Kung H, Peterson EJ, DePaulaRF,Dowden, PC, Stan L, Emmert LA (2001). Development of Large area thin fims by spray pyrolysis deposition. *Journal of Materials Research* **16** (8) P2175-2178,2001.
Groves JR, Arendt PN, Foltyn SR, Jia QX, Holesinger TG, Kung H, Peterson EJ, DePaula RF, Dowden PC, Stan L and Emmert LA (2001), High critical current density YBa2Cu3O7-delta thick films using ion beam assisted deposition MgO bi-axially oriented template layers on nickel-based superalloy substrates. *Journal of Materials Research* **16**(8) 2175-2178.
Wilson JM (1982). A linear source of electrostatically charged spray Original Research Article Pages *Journal of Agriculture Engineering Reseasrch* 355-362 Volume 27, Issue 4, (July 1982)
Jin-Ping Han, Jun Gu and Ma TP (1997). SrBi2Ta2O9(SBT) thin films prepared by electrostatic spray *Integrated Ferroelectrics* **14**(1-4) 229-235
Soo Gil Kim, Jin Yong Kim, Hyeong Joon Kim (2000). Deposition of MgO thin films by modified electrostatic spray pyrolysis method. *Thin solid films* **376** (1–2) 110-114.
Michel Cloupeau, Bernard Prunet-Foch (1994). Electrohydrodynamic spraying functioning modes: a critical review Original Research Article *Journal of Aerosol Science* Pages 1021-1036 Volume 25, Issue 6, (September 1994)
Malozemoff AP, Annavarapu S, Fritzemeier L, Qi L, Prunier V, Rupich M, Thieme C, Zhang W, Goyal A, Paranthaman M and Lee DF (2000). Low-cost YBCO coated conductor technology. *Superconductor Science and Technology* **13**(5) 473-476.
M Parans Paranthaman, T Aytug, H Y Zhai, L Heatherly, A Goyal and D K Christen (2005). Growth of YBCO films on MgO-based rolling-assisted biaxially textured substrates templates Volume 18 Number 3, March 2005 pp 223-228

Paranthaman MP, Sathyamurthi S, Heatherly L, Martin PM, Goyal A, Kodenkandath T, Li X,Thieme CLH, Rupiah (2006). All MOD buffer/YBCO approach to coated conductors Original Research Article. *Physica C* **445–448** 529-532.

Pramod S. Patil (1999). Versatility of chemical spray pyrolysis technique. *Materials Chemistry and Physics* 185-198 Volume 59, Issue 3, (15 June 1999)

Rupick MW, Verebelyi DT, Zwang W, Kodenkadath T and Li XP (2004). Metalorganic deposition of YBCO films for second-generation high-temperature superconductor wires. *MRS Bulletin* **29**(8) 572-578.

Shields TC, Abell JS, Button TW, Chakalov RA, Chacalova RI, Cai C, Haessler W, EickemeyerJ, de Boer B (2002). Deposition of YBCO films by high temperature spray pyrolysis. Physica C 747-750 **372–376** (2) 583-1290.

Shields TC, Kawano K, T W Button and J S Abell (2002). Spray pyrolysis of epitaxial YBCO films on (100) single crystal SrTiO3 substrates. *Superconductor Science and Technology* **15** (1).

Stryckmans O, Segato O and Duvigneaud PH (1996). Formation of MgO thin films by Ultrasonic Spray Pyrolysis form Beta Decketonate. *Thin Solid Films* **283**(1-2) 17-25.

Supardi Z, Delabouglise G, Peroz C, Sin A, Villard C, Odier P, Weiss F (2003). Epitaxial thick film of YBCO by high temperature spray pyrolysis for coated conductors *Physica C* **386** 296-299.

Urade T, Iemori T, Osawa M, Nakayama N and Morita I (1976). A protecting layer for the dielectric in AC plasma panels Electron Devices. *IEEE Transactions* **23(**3) 313-318. Doi: 10.1109/T-ED.1976.18397