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Optimizing Deposition Techniques and Parameters For HIGH TC ybco thin films

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Abstract: In this study, deposition techniques and synthesis parameters are optimised in order to achieve the goal of increasing the critical current density (Jc) and critical temperature (Tc) of thin films made of Yttrium Barium Copper Oxide (YBCO). The thin films of YBCO, which are among the most widely used high-temperature superconducting materials, have a wide range of possible applications in the field of technology. Some of these applications include quantum computing, energy storage, and electronic devices. The microstructure and superconducting properties of films that have been deposited using various deposition techniques, such as magnetron sputtering, chemical vapour deposition (CVD), and pulsed laser deposition (PLD), will be investigated in this study. Additionally, the effects of substrate type, deposition temperature, oxygen pressure, and post-deposition annealing will also be investigated. The main objective of the research is to generate YBCO thin films that are optimised for use in high-efficiency superconducting devices. This will be accomplished by designing and developing these features.

Keywords: Deposition , Parameters , Thin films, YBCO

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INTRODUCTION

High-temperature superconductors (HTS) have garnered a lot of attention as a result of the fact that they have the potential to be used in cutting-edge technologies such as quantum computing, magnetic levitation, medical imaging, and power transmission in the near future. As a result of its ability to carry considerable critical current densities (Jc) without resistance, Yttrium Barium Copper Oxide (YBCO) stands out as one of the most promising of these materials. Its critical temperature (Tc) is around 90 K, which is rather high. The fabrication of YBCO thin films that have superconducting properties that have been optimised is very necessary in order to achieve the full potential of this material in practical devices. These films need to go through the process of optimisation in order to increase their performance. This is because the quality of these films is largely reliant on the deposition techniques and parameters that are employed in their formation.

PLD for its ability to produce crystalline films with precise stoichiometry

A number of different deposition techniques, such as Magnetron Sputtering, Chemical Vapour Deposition (CVD), and Pulsed Laser Deposition (PLD), are used in the process of producing thin films made of YBCO. With regard to the quality of the film, the controllability of the thickness, the rate of deposition, and the scalability, each of these approaches has its own unique set of advantages and disadvantages. Despite the fact that PLD is well-known for its ability to produce crystalline films with precise stoichiometry, the deposition rate that it is capable of achieving is not always very high. CVD, on the other hand, is capable of attaining fast deposition rates, despite the fact that it may be challenging to control the composition of the film. When utilising Magnetron Sputtering, which offers a balance between film quality and deposition rate, it is necessary to properly tune the process parameters in order to achieve high superconducting characteristics. However, in order to produce YBCO thin films with the greatest possible characteristics, it is required to conduct a systematic investigation of deposition parameters such as substrate temperature, oxygen pressure, deposition duration, and post-deposition annealing. This is because these procedures are relatively sophisticated.

Correlation between the substrate and the success of YBCO thin films

There is a strong correlation between the substrate that is utilised and the success of YBCO thin films. The mismatch in the lattice of the substrate material has an effect on the orientation and crystallinity of the YBCO film. It is important to note that the lattice parameters and thermal expansion coefficients of common substrates, such as $SrTiO_3$, $LaAlO_t$, and MgO, demonstrate distinct differences from one another. The superconducting properties of films are influenced by the surface form and lattice structure of the substrates, which in turn have an effect on the nucleation and development of the deposition process.

In order to achieve the desired oxygen concentration in YBCO films, it is necessary to pay close attention to the conditions under which the deposition takes place as well as the annealing process that occurs after the deposition. Annealing the film in an oxygen-rich environment has the potential to significantly increase its superconducting features, such as Tc and Jc. The oxygen stoichiometry in the YBCO lattice is a major factor in the superconductivity of the film. It is necessary to exercise strict control over the annealing temperature, time, and gas composition in order to achieve accurate oxygenation without causing structural damage of the film.

This research aims to improve the superconducting performance of YBCO thin films by carefully refining their deposition techniques and attributes. This will be accomplished within the scope of this investigation. Through the investigation of the interplay between deposition temperature, oxygen pressure, substrate type, film thickness, and post-deposition annealing, the purpose of this study was to give a comprehensive understanding of how to enhance the superconducting properties of YBCO thin films. Providing a mechanism for high-performance YBCO thin films to be used by superconducting devices and technologies of the future generation is the ultimate objective of this optimisation.

OBJECTIVES

1. To improve the superconducting characteristics (Tc and Jc) of YBCO thin films by optimizing deposition methods and factors, such as substrate temperature, oxygen pressure, and film thickness.
2. To assess how substrate choice and post-deposition annealing affect the microstructure, crystallinity, and superconducting capabilities of YBCO thin films.

METHODOLOGY

This study will make use of YBCO target material that is 99.9% pure in order to bring about the fabrication of thin films. It is planned to make use of substrates such as SrTiO2 (SrTiO2), LaAlO2 (LaAlO2), and

MgO in order to investigate the manner in which substrates influence the development and features of YBCO films. RF magnetron sputtering, chemical vapour deposition (CVD), and pulsed laser deposition (PLD) are the three types of deposition technologies that will be used. Materials will be deposited by PLD at temperatures ranging from 700 to 850 degrees Celsius. This is accomplished by using an excimer laser with a wavelength of 248 nanometres and an oxygen pressure of 10-300 milliTorr. The chemical vapour deposition (CVD) method comprises chemical processes that require volatile precursors. These reactions take place under circumstances where the deposition temperatures range from 600 to 800 degrees Celsius and the oxygen partial pressures range from 100 to 500 milliTorr. A variety of Ar/O2 gas flow ratios will be used throughout the RF Magnetron Sputtering process, which will be carried out at substrate temperatures ranging from 650 to 850 degrees Celsius. We will study the effects that a number of optimisation parameters have on the microstructure, crystallinity, and superconducting properties of the material, such as the critical temperature (Tc) and the critical current density (Jc). Deposition temperature, oxygen pressure, substrate type, and film thickness are some of the characteristics that are included in this category. After the film has been deposited, it will be annealed in an oxygen-controlled atmosphere at temperatures ranging from 400 to 800 degrees Celsius.

This will be done in order to increase the stoichiometry and superconductivity of the film. Characterisation techniques such as X-Ray Diffraction (XRD), Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM), electrical transport investigations, and Raman spectroscopy will be used in order to conduct an analysis of the crystallinity, morphology, roughness, Tc, and Jc, as well as the oxygen content. The analysis of the data will include statistical comparisons across the various deposition parameters in order to achieve the goal of improving the fabrication process for high-quality YBCO thin films that have improved superconducting performance and are suitable for advanced superconducting applications.

Preparation Of Sputtering Target

Powders of Y2O3, BaCO3, and CuO that were made with a high purity level of 99.99 percent were employed as the starting material [6]. Weighing, thoroughly combining, and grinding the required amounts of these powders in the cation ratio Y: Ba: Cu = 1:2:3 resulted in the formation of a mixture that was homogeneous. Once that was done, the powder was cold-pressed into four pellets with a diameter of 2.5 centimetres and a density of 3,500 kilogrammes per cubic centimetre. As a result of calcination at 8200 degrees Celsius for six hours, these pellets were extracted. They were crushed once again, compacted into pellets, and then calcined in a stream of oxygen at a temperature of 930 degrees Celsius (100 degrees Celsius per minute) for a period of thirty hours. A second check was performed on this method. At a temperature that was rather high, the pellets were calcined, which facilitated the breakdown of the precursors into oxides and made it possible for diffusional mixing to take place, resulting in the formation of the stoichiometric superconducting phase. There was a disc target with a diameter of two inches that was used in order to push the ground and calcined pellets. After that, the compressed target was sintered in an electrical muffle furnace with flowing oxygen at a temperature of 9400 degrees Celsius for a period of twenty-four hours without stopping. Above 650 degrees Celsius, the orthorhombic superconducting phase of YBCO shows signs of instability. At temperatures ranging from 900 to 950 degrees Celsius, there is a tetragonal structure and a quantity of oxygen that is less than 6.5 moles per formula unit. After being quenched in this condition, the material loses its ability to conduct electricity effectively. Therefore, in order to recover the oxygen to a level that is close to seven, the material must be annealed in oxygen or air for a considerable amount of time at temperatures ranging from 400 to 500 degrees Celsius. After the sintering process, the furnace was progressively cooled to 450 degrees Celsius at a rate of 10 degrees Celsius per minute. Following an initial period of 72 hours at this temperature, the target was progressively brought down to room temperature. The finished product had a YBCO target that was black in hue. The density of the target was 5.6 grammes per square centimetre. It was found that the fragmented targets had temperature coefficients (R=0) that varied from 89 to 92K. X-ray diffraction (XRD) analysis reveals that the targets only have one phase (123). X-ray diffraction (XRD) of a very small YBCO target fragment is shown in Figure 1.

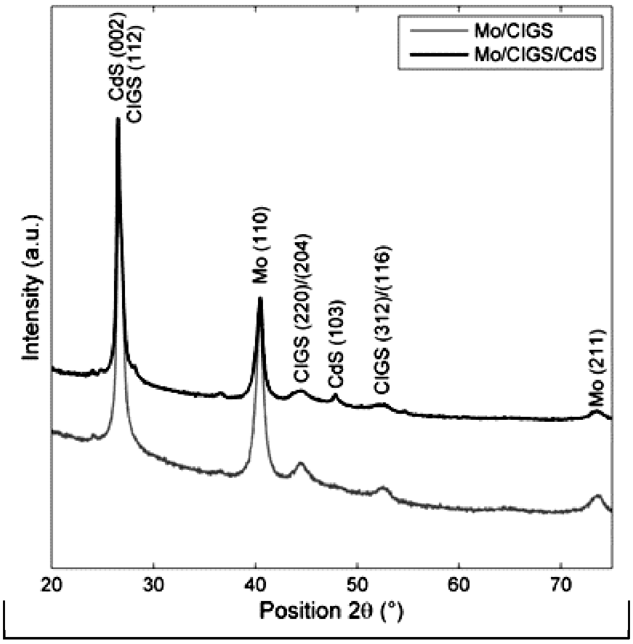

Figure 1. XRD pattern of a tiny dc magnetron sputtering system YBCO target

Deposition System For Preparation Of Ybco Thin Film

In order to deposit the thin coating, the conventional method of direct current magnetron sputtering was used, and a single YBCO (123) target was required. The reduced configuration of our sputtering system is shown graphicalally in Figure 2. The deposition system is made up of a high-vacuum chamber that is helped by a diffusion pump and maintains a base pressure of 10-6 Torr. Because of the liquid nitrogen trap that has been inserted in the vacuum line, the high vapour pressure fluids that are utilised in these pumps are unable to flow backwards. The components that comprise this system are as follows: a dc magnetron-sputtering gun (Ion Tech. B 315, United Kingdom), a substrate heater (Conductus, United States of America), a gas assembly, a shutter, and a chromel-alumel thermocouple that is linked close to the substrate. In the deposition chamber, the planar magnetron-sputtering gun is positioned on the top flange, which is parallel to the base plate throughout the installation process. Permanent magnets are located in the magnetron cannon, which is located just beneath the cathode. Discharge plasma is only permitted to enter a tiny zone that is immediately around the cathode surface where it is placed. The target has the appearance of a disc, and the planar substrate holder is positioned such that it faces the toroidal plasma ring. A condition of equilibrium is maintained in the plasma that is enclosed immediately above the substrate holder. The magnetron sputtering process only causes the target to degrade in the zone that is surrounded by a transverse magnetic field. In front of the target, the transverse component of the magnetic field typically has values of around 500G per unit of acceleration. It is possible for the direct current (DC) magnetron source to function at low cathode voltages ranging from 100 to 200V when it is powered by a direct current (DC) power source developed by MegaTech Ltd. An anode is provided by the grounded substrate heater, which has the capability of reaching temperatures of up to 900 degrees Celsius. A thermocouple is put under the surface of the heater, not too far away from the location of the substrate, in order to determine the temperature of the heater.

Figure 2. Diagrammatic representation of the dc magnetron sputtering technique used to produce thin films

For the purpose of calibrating the substrate temperature as a function of heater temperature, a microprocessor-controlled temperature indicator-cum-controller (Thermotech, L 2001) was used. This controller had a margin of error of less than one degree Celsius. Throughout the whole of the deposition process, a Baratron gauge, specifically an MKS Model 220C, was used to keep track of the overall absolute pressure. By using a needle valve to allow the gas mixture (Ar: O_2) to enter the vicinity of the target, this gauge was able to maintain a constant level. For the purpose of determining the partial pressure of the sputtering gases, a mass flow controller known as the MKS PDR-C-1C was used.

SECTION TITLE 4

Fabrication of High-Tc Superconducting Ybco Thin Films

High-grade superconducting YBCO thin films were deposited utilising on-axis single target magnetron sputtering. High-vacuum chambers are part of deposition equipment.An absolute vacuum of 1x10-6 Torr was achieved using a diffusion pump and liquid nitrogen trap. The deposition chamber had a planar magnetron sputter gun (Model B-315, Ion Tech, UK) on top. Silver paste was used to glue the 50 mm diameter and 3 mm thick single phase stoichiometric YBCO (123) target to a 2-inch copper plate of a planar magnetron cathode for optimum thermal and electrical contact. An anode heater block (Conductus, USA) was below the cathode in the on-axis configuration. The cleaned and polished substrate was bonded to the heater block using conductive silver paste. Plotting the substrate temperature versus the heater temperature calibrated it. A digital temperature indicator-cum-controller (Thermotech L-2001) measured substrate temperature using a chromel-alumel (type K) thermocouple attached to the heater block near the substrate. An hour of low plasma current shutter pre-sputtering between the cathode and heater block cleaned the target surface of contaminants. After meeting thin film deposition requirements such temperature, gas pressure, substrate-target distance, etc., the shutter was removed. Deposition occurred at substrate temperatures between 650 and 760 °C.

Sputtering gas pressure was monitored and regulated using a piezoelectric control valve and MKS PDR-1C digital capacitance manometer. The films were deposited using 2:1 argon-oxygen sputtering gas. Sputtering pressure was 300–1000 mTorr when depositing the mixture. Target and substrate were 25–35 mm apart.

The films were deposited with a plasma current of 175 to 425 mA and a cathode voltage of -120 V using a MegaTech Ltd. MDS-1K dc power supply.High-Tc superconducting YBCO (123) thin films were deposited in situ on single crystal SrTiO3 substrates. To avoid film surface oxygen depletion after film deposition, the sputtering chamber was supplied with pure dry oxygen at 300 Torr. Reducing the substrate temperature to 475oC took 2oC each minute. This technique involves a phase shift from tetragonal to orthorhombic structure C) in the YBCO thin film for 1 to 2 hours, followed by progressive cooling to ambient temperature. The film stayed at 475ºC. Optimising substrate temperature, gas pressure, and other parameters led to optimal layer deposition on a (100) SrTiO3 substrate. As-deposited film was black, shiny, and smooth. This method could not avoid major target fractures. Plasma current was 50 mA before stabilisation. The plasma current was then steadily increased to the desired level. Cooling the target with water stopped it from shattering. This method allowed the targets to last 60 hours without cracking. Prolonged sputtering drastically alters the target's composition, making it unsuitable for producing stoichiometric YBCO (123) films.

Table 1. High-quality YBCO thin films on SrTiO3 (100) substrate via dc magnetron sputtering under optimised deposition conditions

Parameter	Value
Target	Superconducting single-phase YBaCuO (123)
Substrate	Single crystal (100) $SrTiO_3$
Substrate-Target Distance	35 mm
Sputtering Gas Pressure ($Ar:O_2 = 2:1$)	850 mTorr
Substrate Temperature	740°C
Plasma Current	250 mA
Cathode Voltage	~120 V
Deposition Time	2 hours
Hold Temperature	475°C
Hold Time	2 hours

Table 2 YBCO thin film properties at optimised conditions

Property	Value
Critical Temperature (Tc)	90-91.15 K
Critical Current Density (Jc)	1.0-1.5 x 10^6 A/cm²
Orientation	Fully c-axis
Film Thickness	350-370 nm

Sputtering Parameters Affecting Growth And Superconducting Properties Of Ybco Thin Film

Role of oxygen

While YBCO is being deposited on SrTiO3, oxygen is a component that is absolutely necessary. It does this by oxidizing the sputtered species when they land on the substrate and condense, which results in the formation of the material's essential phase. During the sputtering process, it continues to maintain high oxygen levels on the target surface. At an atmospheric pressure of 800 mTorr, a gas mixture that was composed of argon and oxygen was used during the sputtering process. Following the completion of the deposition process, the sputtering chamber was subsequently evacuated and then filled with pure dry oxygen (IOLAR-I) to a pressure of 300 Torr.

Effect of power

Cathode voltage cannot influence plasma characteristics since this approach uses the usual glow discharge zone of dc plasma, which is the constant voltage region. The cathode current has been shown to have a significant influence on the characteristics of the film, according to extensive research. Additionally, the sputtering rate of the YBCO target is determined by the plasma current. The process of magnetron sputtering is dependent on the plasma YBCO supply being matched to the surface kinetics-determined optimal growth rate at a particular temperature. When it comes to the production of high-quality film, the cathode voltage, which is determined by the conductivity of the target, is a vital measure to consider. Ion energies are lowered to ranges of a few hundred electron volts as a result of the decreased cathode voltage throughout the process. The use of a target that is deficient in oxygen results in an increase in cathode voltage, which in turn results in a decrease in film quality. The surface roughness, on the other hand, increases in tandem with the increase in the plasma circulation. Variations in surface morphology are evident in thin films of YBCO that were deposited under optimised sputtering conditions for three hours at various plasma currents. Surface roughness was observed to increase with increasing plasma current. Spiral development generates a bigger rise in surface roughness. However, excessive surface roughness must be avoided in building planar or multilayer tunnel connection devices based on grain boundary alignment. The scanning electron micrographs of the YBCO thin films produced on the SrTiO3 substrate employing different plasmacurrents indicate a glossy, flat surface. In addition, films generated at high plasma currents (>350mA) do have some of the target components on their surface. A typical YBCO thin film generated at a high plasma current of around 350mA is illustrated in Figure 6, which is a SEM picture. Photos acquired with a scanning electron microscope demonstrate that YBCO films, when grown on a SrTiO3 substrate under optimal conditions, have surfaces that are relatively smooth and absent of surface flaws such as voids, mechanical cracks, surface outgrowth, and precipitates.

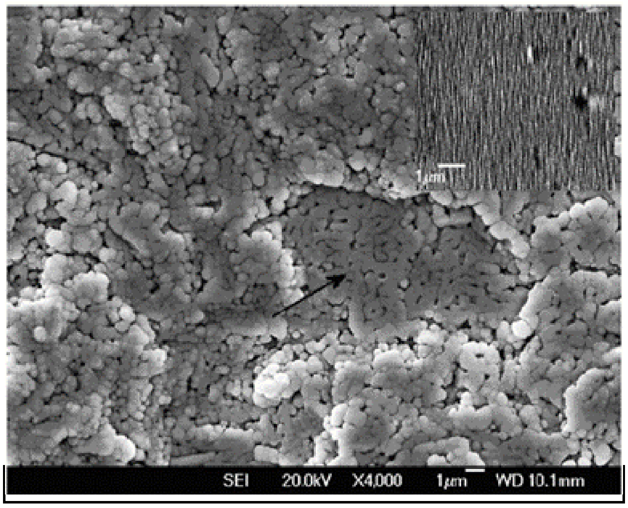

Figure 3. SEM picture of a typical YBCO thin film deposited at high plasma current ~350mA.

Effect of substrate temperature

There was a considerable correlation between the temperature of the substrate and the tendency of the thin film to grow in a certain direction and to exhibit superconducting properties. As temperatures drop, cations lose some of their mobility, which means that they may not be able to return to the locations where they normally reside. Due to the exponential increase in atomic mobility, the degree of disorder diminishes rapidly as the growth temperature increases. This is because of the nature of the growth. At higher growth temperatures, atomic mobility is sufficient to build a structure that is completely organised inside its whole. The temperature of the substrate is one of the most important parameters since it determines the surface energies, relaxation, surface self-diffusion, and the possibility of adatoms and ad molecules adhering together. There is a possibility that the atomic mobility of the components is not sufficiently high to ensure epitaxial growth at medium temperatures for the substrate. When the temperature of the substrate is increased to a point where the mobility is sufficiently high, it is possible for films to be created that have a structure that is virtually completely ordered. Another thing that has been shown is that the critical current density Jc is influenced by the temperature of the substrate [9]. A Jc (at 77K) of roughly 104A/cm2 was observed in films that were formed at a substrate temperature of 650 degrees Celsius. The Jc (T=77K) for films that were deposited resulted in roughly 106A/cm2 when the substrate temperature was around 750 degrees Celsius. It was determined how large the grain sizes of the YBCO films were by using a scanning tunnelling microscope (STM). It was possible to get a larger grain size by increasing the temperature of the substrate from 700 to 740 degrees Celsius. Table 3 illustrates the relationship between grain size and the temperature of the substrate.

Table 3. Dependence of grain size of thin films on substrate temperature

Sample No.	Substrate Temperature (°C)	Grain Size (nm)
1	700	327 x 523
2	720	964 x 910
3	740	7179 x 7170

Effect of substrate- target distance

It was possible to generate thin films with good superconductivity by using substrates with thicknesses ranging from 25 mm to 35 mm, which were located slightly below the glow coming from the negative discharge. The films that were deposited will not be uniform if the distance between the substrate and the target, denoted by dS-T, is less than 25 millimetres. During the course of its development, the film was subjected to a barrage of excited neutrals and negatively charged ions, which resulted in the non uniformity that was seen in smalldS-T.

Effect of sputtering gas pressure

Increasing the collision frequency while maintaining a reasonably high gas pressure causes the energy of the negative oxygen ions to decrease before they reach the substrate. The production of high-quality YBCO films was accomplished by using a onaxis arrangement, a sputtering gas pressure of 400 mTorr or more, and avoiding the re-sputtering effect. A high gas pressure of 800 mTorr was used to make the thin films that had a surface morphology that was smooth and a high temperature content (Tc) of 91K. This was due to the fact that the dangerous ions had already been thermalised by the time they reached the substrate, which was made possible by the vast number of collisions before they arrived. When the depositing pressure was lower than 300 mTorr, the film materials displayed a significant amount of repetition of the sputtering process. The electrical conductivity of the layers that have been formed is low when the temperature is at room temperature. Sputtering gas pressures ranging from 600 to 1000 mTorr were used to determine the Tc, which varied from 86 to 91K. A gas pressure of 600 mTorr was used to deposit the film, which had a Tc value of 86K prior to the process. An increase in the critical temperature (Tc) from 86 to 91 degrees Kelvin is brought about by pressures of up to 850 mTorr. Following the point at which the gas pressure surpasses 850 mTorr, the critical temperature remains at 90 K and does not increase any further thereafter. At high pressures, the negative oxygen ions that are produced by the resputtering processes undergo thermalisation. This occurs as a consequence of an increase in the number of collisions with gaseous ions. A significant portion of the energy that the ions with high energies possess is lost before they come into contact with the substrates.

Effect of substrate material

When selecting a substrate, it is essential to take into consideration a number of aspects, such as the cost, the lattice matching, the compatibility between the film and the substrate, and the thermal expansion coefficient matching. The resistance of the thin layer that was formed on the (100) SrTiO3 substrate was shown to be the lowest when the temperature was at its usual level. In light of the fact that the crystal lattices of the film and the substrate are so comparable, this should take place since the thin film's internal tensions are preserved to a lesser extent. It was established that the resistivity ratio R300K/R100K was at its highest point (around three) for films that were generated on a substrate consisting of 100 percent SrTiO3.

Table 4. Properties of substrate material SrTiO3used for high-Tc superconductors

Property	Value
Substrate Material	$SrTiO_3$
Crystal System	Cubic
Lattice Constant (nm)	a = 0.3905
Thermal Expansion Coefficient (10^{-6}/°C)	>200
Loss Tangent (x10^{-4}) at 77K	300
Dielectric Constant	2080
Melting Temperature (°C)	>2000
Percentage Mismatch with YBCO (a = 0.386 nm)	-1.15

Effect of surface quality of substrates

It is necessary for the surface of the substrate to be smooth in order to manufacture epitaxial thin films of superior quality. Roughness is often seen on the surfaces of thin films that are formed on substrates that have undergone such deterioration. The roughness might be the result of crystallites developing off-plane along the c-axis, visible protrusion from the surface, or clusters of crystallites along the a-b axis that are isolated from one another. The same is true for films that are deposited on rough surfaces; step edge Josephson weak connections may appear if the substrate is not polished to an appropriate degree. Because of this, the Jc of the film is greatly decreased, which is a result of this. After being cleaned using tri-chloroethylene and acetone, the substrates were put through an ultrasonic cleaning process. After this, they were annealed in a tube furnace (Tempress, Model 201) with flowing oxygen for a period of two hours at temperatures ranging from 900 degrees Celsius to 1000 degrees Celsius. This was done before they were put on the heater block. The findings of the atomic force microscopy (AFM) examination of the surface morphology of the SrTiO3 substrate are shown in Table 5. A considerable reduction in the surface roughness of the substrate was observed after the annealing process that took place under flowing oxygen.

Table 5. Atomic Force Microscopy (AFM) data on the surface morphology of the SrTiO3 substrate

Sample No.	Substrate	Annealing Condition	RMS Roughness (nm)
1	$SrTiO_3$(100)	Unannealed	1.00
2	$SrTiO_3$(100)	900°C for 2 hrs. in flowing O_2	0.10
3	$SrTiO_3$(100)	1000°C for 2 hrs. in flowing O_2	0.02

Surface Growth Morphology

As a result of the fact that SrTiO2 (Strontium Titanate) has a crystalline surface, the surface growth morphology of this material often exhibits a cubic crystal structure that is characterised by terraces and atomic steps. The processes of thin film deposition are dependent on the presence of grain boundaries, step bunching, and surface defects. These morphological traits are necessary for the operations. Because of the influence that these features have on the nucleation and development of thin films, such as YBCO, they have an effect on the crystallinity and smoothness of the films. Both the degree to which SrTiO2 is able to integrate into high-temperature superconducting applications and the degree to which it can grow epitaxially are highly controlled by the surface form of the material.

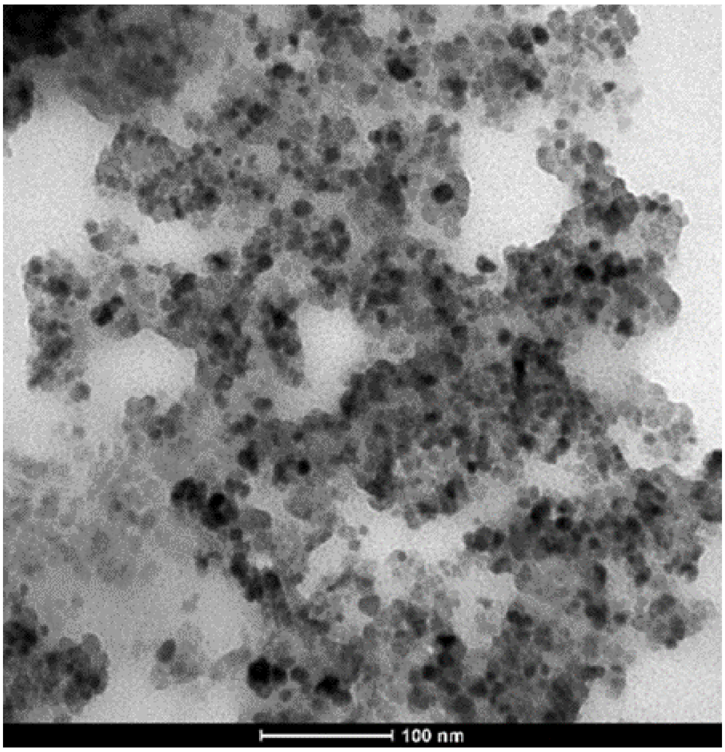

Figure 4. The surface growth morphology of the $srtio_3$ (strontium titanate)

CONCLUSION

This study evaluated a number of different deposition processes and parameters in a systematic manner with the goal of enhancing the superconducting properties of high-Tc YBCO thin films. A significant impact was exerted on these parameters by the critical current density (Jc), microstructure (Tc), and oxygen pressure (O2) during the deposition process. Additionally, substrate selection and post-deposition annealing were also significant contributors to this effect. There are a few different deposition procedures that have been discovered to boost the crystallinity and superconducting properties of YBCO films. These processes include Magnetron Sputtering, Chemical Vapour Deposition (CVD), and Pulsed Laser Deposition (PLD). It was found that the degree to which substrate materials such as $SrTiO_3$, $LaAlO_3$, and MgO were lattice mismatched with YBCO had an effect on the film quality and Tc. Through post-deposition annealing, which ultimately led to an increase in superconductivity, other consequences included an improvement in film stoichiometry as well as an adjustment in oxygen content. The optimized YBCO thin films displayed higher Tc values, which suggests that they might be employed for advanced superconducting applications. These films were made using sheets that were totally aligned along the c-axis and received an increase in Jc. This work highlights the need of rigorously managing the deposition conditions in order to ensure that high-Tc YBCO thin films are used appropriately in real superconducting devices and technologies.

References

1. Shailaj Kumar Shrivastava. Deposition techniques for high-Tc superconducting YBCO thin films. International Journal of Scientific and engineering Research (IJSER), 5(6), June 2017, 33-43,

2. Jian Yang, Dong qi Shi, XiaohuaWango, Anshen Liu, Guansen Yuan. Fabrication of YBCO coated conductor using magnetron sputtering. Physica C: Superconductivity. Vol. 341-348, Part 4, Nov. 2000, 2499-2500

3. Li, J., Ren, G.K., Chen.J. et.al. Facilitating complex Thin Film Deposition by using Magnetron Sputtering: A review. JOM, 74, 3069-3081, (2022). https://doi.org/10.1007/s11837-022-05294-0

4. Amir A. AbdulHussein,Adi Abdul Hussein, Noor A. Hasan. Study of properties of YBCO superconductor compound in various preparation methods: A Short Review. Journal of Applied Sciences and Nanotechnology.Vol.3, No.1, 65-79, 2023

5. X.Z. Liu, Y.R.Li, B.W. Tao, A, Luo, S.M. He. The effect of deposition rate on the microstructure of YBCO thin films prepared by inverted cylindrical magnetron sputtering. Physica C, 371(2002), 133-138

6. Shailaj Kumar Shrivastava. Synthesis of High-TcSuperconducting Cuprate Materials through Solid State Reaction Route. International Journal of Engineering, Science and Mathematics (IJESM), Vol. 7, Issue 3, March. 2018, 91-95 ISSN 2320-0294

7. L.M. Wang, H.W. Yu, H.C. Yang, H.E. Horng. Optimum sputtering conditions on the insitu growth of superconducting YBa2Cu3O7-x films with an off-axis RF sputtering configuration. Physica C, 256, (1996) 57-63

8. M. Reiner, T. Gigi, R. Jany, G. Hammeri, and C. Huge Schmidt. Impact of oxygen diffusion on superconductivity in YBa2Cu3O7- x thin films studied by positron annihilation spectroscopy. Phys.Rev. B, 97, 144503, 4April 2018.

9. Tran HaiDuc, Duong ThiThanhNhan, Nguyen HuySinh. Effect of substrate temperature on the critical current density in the YBa2Cu3O7-x superconducting films. VNU Journal of Science: Mathematics-Physics. Vol.32. No.2 (2016)8-14

10. Shailaj Kumar Shrivastava. "Surface sensitive techniques for probing surface structures and surface morphology" Proceedings of the 3rd International Conference on Interdisciplinary Research innovations in Science and Humanities 29 and 30 Nov. 2017 at Bangkok, Thailand. ISBN-978-93-86659-11-8. Publisher: P. Duraiswami, Hikey Media, Chennai-600014

11. Aperis, P. Maldonado, and P. M. Oppeneer, Phys. Rev. B 92, 054516 (2015). X. X. Xi, Rep. Prog. Phys. 71, 116501 (2008).

12. J. Gutierrez, B. Raes, A. V. Silhanek, L. J. Li, N. D. Zhigadlo, J. Karpinski, J. Tempere, and V. V. Moshchalkov, Phys. Rev. B 85, 094511 (2012).

13. R. Geurts, M. V. Milosevi ˇ c, and F. M. Peeters, ´ Phys. Rev. B 81, 214514 (2010).

14. M. V. Milosevi ˇ c and A. Perali, ´ Supercond. Sci. Technol. 28, 060201 (2015)