

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

اللَّهُ نُورُ السَّمَاوَاتِ وَالْأَرْضِ ۗ مَثَلُ نُورِهِ

كَمِشْكَاتٍ فِيهَا مِصْبَاحٌ ۗ الْمِصْبَاحُ فِي زُجَاجَةٍ

ۗ الزُّجَاجَةُ كَأَنَّهَا كَوْكَبٌ كَرِيهُ يُوقَدُ مِنْ

شَجَرَةٍ مُبَارَكَةٍ زَيْتُونَةٍ لَا شَرْقِيَّةٍ وَلَا غَرْبِيَّةٍ يَكَادُ

زَيْتُهَا يُضِيءُ وَلَوْ لَمْ تَمْسَسْهُ نَارٌ ۗ نُورٌ عَلَى نُورٍ ۗ

يَهْدِي اللَّهُ لِنُورِهِ مَن يَشَاءُ ۗ وَيَضْرِبُ اللَّهُ الْأَمْثَالَ

لِلنَّاسِ ۗ وَاللَّهُ بِكُلِّ شَيْءٍ عَلِيمٌ (35)

صدق الله العظيم

# DEDICATION

**TO MY FATHER AND MOTHER**

**TO ALL OF MY LOVELY FAMILY MEMBERS**

**TO MY COLLEAGUES**

**TO YOU**

## ACKNOWLEDGEMENT

First of all, I would like to express my sincere gratitude to the supportive supervisor, **Prof. Dr. Abdelmoneim Mohamed Awadalgied** who has dedicated support, guidance, and enthusiastic to assist in any way he could throughout the research project. Besides my advisor, I would like to thank **Prof. Dr. Nafie Abdallatief Almuslet** for the continuous support of my Ph.D. study and related research, for his patience, motivation, and immense knowledge. His guidance helped me in all the time of research. Also many special thanks to my labmates for stimulating discussions and valuable comments.

Besides, I would like to express my sincere gratitude to the department of science and technology, government of India for the financial support provided under the C V Raman fellowship for African researchers program in India institute of science (iisc), Bangalore, India. My sincere thanks also go to **Prof. Shankar Kumar Selvaraja** provided me an opportunity to join his team as an intern, and who gave access to the laboratory and research facilities. Without his precious support, it would not be possible to conduct this research. Furthermore, I am also thankful to the staff of the Centre for Nano Science and Engineering (CeNSE) for all the considerate assistance and guidance.

I cannot forget to thank my family and friends for all the unconditional support in this very intense academic year. To all of the people who sacrificed their souls to warrantee a brilliant future for the coming Generations finally, I would like to acknowledge all of my fellow's member staff of the institute of laser for all the considerate guidance and support.

# Abstract

In this work, the influence of annealing temperature and the variation of the thermal stability during the deposition were investigated. Pulsed laser deposition system was capable of manufacturing two groups of  $\text{La}_2\text{Ti}_2\text{O}_7$  thin films on Si (100) substrate at different annealing temperatures based on the pulse rate frequency 3 and 4 Hz for 85 and 64 minutes, respectively. Both groups of samples were deposited with a KrF excimer laser with fixed parameters at different annealing temperatures 25, 400, 450, 500, 600, 650, and 700 °C, separately. In order to study the effect of temperature on the microstructure, optical properties of  $\text{La}_2\text{Ti}_2\text{O}_7$  films, the fabricated films were investigated using x-ray diffractometer (XRD), scanning electron microscope (SEM) associated with energy dispersive x-ray spectrometer (EDS), atomic force microscopy (AFM), and the ellipsometry.

The XRD patterns of the LTO target and films were analyzed into monoclinic structural and an amorphous nature, respectively. While the EDS spectra confirmed that, the film's chemical composition was of lanthanum, oxygen, titanium with the disappearance of any impurities.

The SEM images illustrated that the average thicknesses of the LTO thin films were found to be decreased linearly with the increasing of annealing temperatures for the thin films that were deposited in 3 and 4 HZ together.

The AFM reported that all the LTO film were smooth, dense, and uniform. At room temperature, the highest roughness was recorded for the two groups of thin films then become smoother when the temperature increased up to 500 °C, and they were slightly rougher with the increase of temperature up to 700 °C for both groups of films were deposited with 3 and 4 Hz.

The obtained results from the ellipsometry pointed out that the refractive indices of the first group of LTO films in the wavelength range of (400–

1000) nm is within (2.42 – 2.12) changing with the annealing temperatures with the variation of 0.09, particularly at 1000 nm. While it was found within (2.38 to 2.11) changing with the annealing temperatures as well with a small variation of 0.12 specifically at the 1000 nm for the second group of LTO films. As such as the refractive indices of both groups reduced with the increasing of wavelengths following a normal dispersion. On the other hand, the extinction coefficient of the two groups was invariable rose as the temperature rises up to 700 °C together. Further, the real part of the dielectric constant of LTO films in the wavelength range 400–1000 nm is within (4.43 – 5.90) and (4.47 – 5.67) adjusting with the different annealing temperatures for the first and the second group, respectively. While the imaginary part of the dielectric constant of the two groups gradually increases (with peaks shift) during the temperature rises from 25 to 700 °C. Furthermore, the maximum depolarization at 450 nm was found (65%) and (28%) when the thin films deposited with 600 °C and 450 °C for the first and the second group, respectively. While the minimums depolarization were (3%) for the both groups at the same wavelength.

Based on the achieved results from the XRD, SEM, AFM, EDX, and ellipsometry, it can be concluded that the annealing temperature controls the characteristics of the LTO thin films.

## المستخلص

في هذا البحث، تم التحقق من تأثير درجة حرارة التلدين وتغير الشبات الحراري أثناء الترسيب. أستخدم الترسيب بالليزر لتصنيع مجموعتين من الشراخ الرقيقة للانثانوم أكسيد التيتانيوم علي السيليكون (100) بصورة فعالة بترددات 3 و 4 هيرتز ل 85 و 64 دقيقة علي التوالي. كلتا المجموعتين تم ترسيبها بطريقة منفصلة بواسطة ليزر الاكسايمر فلورايد الكريبتون بمعاملات ثابتة تحت درجات حرارة تلدين مختلفة 25 و 400 و 450 و 500 و 600 و 650 و 700 درجة مئوية. من أجل دراسة تأثير درجة حرارة التلدين علي الخصائص البصرية والتركيبية المجهرية لشراخ اللانثانوم اوأكسيد التيتانيوم تم التحقق من الشراخ الرقيقة المصنعة بواسطة جهاز حيود الأشعة السينية (XRD) و مجهر الماسح الإلكتروني (SEM) مرتبط به مطياف الطاقة الموزع بالأشعة السينية (EDS) و مجهر القوة الذري (AFM) و مقياس استقطابية الضوء.

تم تحليل أنماط جهاز حيود الأشعة السينية (XRD) للانثانوم أكسيد التيتانيوم المستخدم كهدف بنظام بلوري أحادي الميل و الشراخ الرقيقة المصنعة بأنها طبيعة غير متبلورة. بينما أكدت الأطياف بمطياف الطاقة الموزع بالأشعة السينية أن التركيب الكيميائي للشراخ الرقيقة هو من اللانثانوم والاكسجين والتيتانيوم مع عدم وجود أي شوائب بالشراخ الرقيقة.

أوضحت صور المجهر الإلكتروني الماسح أن متوسط سماكة شراخ اللانثانوم أكسيد التيتانيوم الرقيقة أنخفض بشكل خطي مع زيادة درجات حرارة التلدين للشراخ الرقيقة المرسبة بترددات ال 3 و 4 هرتز.

وصف مجهر القوة الذري أن كل شراخ اللانثانوم اوأكسيد التيتانيوم كانت ملساء، كثيفة و منتظمة، حيث سجل أعلى مستوي خشونة عند درجة حرارة تلدين تساوي درجة حرارة الغرفة للمجموعتان و أصبحت أكثر نعومة مع زيادة درجة حرارة التلدين الي 500 درجة مئوية ثم أصبحت أكثر خشونة بزيادة درجة الحرارة الي 700 درجة مئوية لكلتا المجموعتين المرسبتين في ترددات 3 و 4 هيرتز.

أشارت النتائج المتحصل عليها من مقياس استقطابية الضوء إلى أن معامل الانكسار للمجموعة الاولي لشراخ (LTO) للاطوال الموجية من 400-1000 نانوميتر يتراوح من (2.42 الي 2.12) تتغير مع تغير درجات حرارة التلدين حيث وجد انها تغيير بقيمة 0.09 بالضبط عند الطول الموجي 1000 نانوميتر. بينما كان معامل الانكسار للمجموعة الثانية لشراخ (LTO) للاطوال الموجية من 400-1000 نانوميتر يتراوح من (2.38 الي 2.11) تتحدد

مع تغير درجات حرارة التلدين المختلفة حيث وجد انها تتغير بقيمة 0.12 عند الطول الموجي 1000 نانومتر على وجه التحديد. كما وجد أن معاملات الانكسار لكلا المجموعتين يتناقص مع تزايد الأطوال الموجية متوافقةً بذلك مع التشتت الطبيعي. ومن ناحية أخرى كان معامل الإندثار للمجموعتان يرتفع بشكل ثابت عندما ترتفع درجة الحرارة إلى 700 درجة مئوية. بالإضافة إلى ذلك وجد ان الجزء الحقيقي من ثابت العزل الكهربائي لأغشية (LTO) في مدى الاطوال الموجية من 400 الي 1000 نانومتر يقع ضمن (4.43 - 5.90) و (4.47 - 5.67) تتحدد مع درجات حرارة التلدين المختلفة للمجموعة الأولى والثانية على التوالي. بينما يزداد الجزء التخيلي من ثابت العزل للمجموعتان تدريجيًا (مع تغير في القمم) أثناء ارتفاع درجة الحرارة من 25 إلى 700 درجة مئوية. أيضا كانت أقصى نسبة ازالة للأستقطاب عند 450 نانومتر (65٪) و (28٪) عندما ترسبت الأغشية الرقيقة بدرجة حرارة 600 درجة مئوية و 450 درجة مئوية للمجموعة الأولى والثانية على التوالي. بينما كانت ادناها (3٪) للمجموعتان عند نفس الطول الموجي.

استناداً إلى النتائج التي تم الحصول عليها من جهاز حيود الاشعة السينية والمجهر الإلكتروني الماسح ومجهر القوة الذري و مقياس استقطابية الضوء نستخلص أن درجة الحرارة التلدين تتحكم في خصائص الشرائح الرقيقة للثانوم أكسيد التيتانيوم.

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