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A REVIEW ON CHARACTERISTICS OF TITANIUM BASED THIN FILMS

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Abstract - *In this paper, we reviewed researches about the titanium based coatings. These coatings were deposited by the various physical technologies like RF magnetron Sputtering, DC Magnetron sputtering, etc. These technologies are used for the processing of thin films and coatings for different applications such as automobile and aerospace parts, computer disc drives and surgical/medical instruments. Mechanical properties of coatings such as wear resistance, hardness and the scratch resistance, structural characteristics, physical and other properties like Optical properties, coatings adhesion into different substrates, wetting behavior and corrosion resistance were studied. Thus, this paper represents a source of information for those who want to familiarize with the status of knowledge in the area of materials science of functional coatings, in particular Titanium based thin films.*

***Key Words*: Titanium, Sputtering, Wettability, Electrical resitivity, Hardness.**

1. INTRODUCTION

Titanium oxynitride is a standout amongst the most seriously contemplated progress metal oxynitride systems, whereas properties of titanium oxynitride depend altogether on the N/O proportion**[1]**. Titanium oxynitride films can be developed with various oxygen substance, covering the unadulterated covalent nitride compound to the ionic oxide . The last x y properties of the films are identified with the synthetic arrangement and homogeneity, just as the crystallographic structure **[2]**. Titanium nitride and titanium oxynitride films were kept by fluctuating the plasma current thickness from 10 mA/cm2 to 40 mA/cm2 utilizing DC magnetron sputtering at steady gas stream rate and testimony time. Titanium nitride and titanium oxynitride hued films are pulled in because of its shopper requests in trimming ventures. Titanium nitride and titanium oxynitride shaded films were arranged at various plasma current densities utilizing DC magnetron sputtering framework at a steady gas flow rate and affidavit time. **[3]**

2. Literature review

Alves *et al.* (2004) had work on titanium oxynitride mixes display fascinating properties for applications with regards to fields running from protective decorative coatings to sun based boards. The properties of TiNxOy are identified with the oxide nitride proportion and can be custom fitted playing with this proportion. The stage arrangement can be custom-made by the substrate predisposition controlling the oxygen fuse. It is essentially the oxygen reactivity and motor vitality of the impinging particles that decide the film properties. **[4]**

Banakh *et al.* (2014) had work on titanium oxynitride coatings (TiNxOy) are viewed as a promising material for applications in dental Implantology because of their high consumption opposition, their biocompatibility and their prevalent hardness. titanium oxynitride slim films kept by reactive magnetron sputtering have pulled in much consideration due to their high application potential in biomedical gadgets and numerous reports were dedicated to the organic reaction of TiNxOy. Titanium oxynitride coatings with substance organizations ranging from TiN to TiO2were saved by magnetron sputtering using a metallic Ti target and a blend of O2+ N2as responsive gases. **[5]**

Braic *et al.* (2007) The enthusiasm for TiNxOy films has expanded as of late because of their properties reliance on the N/O proportion. In this work, we considered relatively the impact of various stream rate proportions of the responsive gases (O2 and N2) on the properties of the TiNxOy films kept by two distinct strategies. Over the previous decade, there was a significant enthusiasm for the investigation of different transitional oxy-nitride dainty films, due to their exceptional optical and electronic properties, mechanical conduct and substance security. The way that roughly the equivalent measure of TiNO is framed in films stored by RPM and RF PLD at fundamentally extraordinary O2/N2 proportion recommends that the RF PLD strategy improves the arrangement of TiNO synthetic securities, indeed, even at a low oxygen content. **[6]**

Barhai *et al.* (2010) had work on titanium nitride and titanium oxynitride films were kept by fluctuating the plasma current thickness from 10 mA/cm2 to 40 mA/cm2 utilizing DC magnetron sputtering at steady gas stream rate and testimony time. Titanium nitride and titanium oxynitride hued films are pulled in because of its shopper requests in trimming ventures. Titanium nitride and titanium oxynitride shaded films were arranged at various plasma current densities utilizing DC magnetron sputtering framework at a steady gas flow rate and affidavit time. **[7]**

Chan *et al.* (2009) had work on X-ray photoelectron spectroscopy analyses of titanium oxynitride films prepared by magnetron sputtering using air/Ar mixtures. X-ray photoelectron spectroscopy (XPS) has been utilized to examine titanium oxynitride (TiNxOy) films arranged by D.C. magnetron sputtering utilizing air/Ar mixtures, which enables one to perform the affidavit at a high base weight (1.3×10−2 Pa) and can lessen considerably the handling time. TiNxOy films were set up by utilizing air rather than ordinarily utilized N2/O2 as the receptive gas in physical vapour affidavit (PVD). TiNxOy slight films with either nitrogen-rich or oxygen-rich fixations have been effectively arranged by d.c. magnetron sputtering utilizing air/Ar blends. XPS investigations showthat all readied TiNxOy films displayed a blend of Ti– N– O, Ti– N and Ti– O synthetic restricting states. **[8]**

Chan *et al.* (2012) had work on the title air was utilized as a responsive gas noticeable all around/Ar vaporous blend for sputtering to deliver TiN, TiNxOy, and N-doped TiOx slight films. Air-based statement directed in a low-vacuum base weight condition can diminish generously the general handling time. The aim of this work is to determine processing windows for the air-deposition of aforementioned thin films. The processing windows of air-based kept TiN, TiNxOy (crystalline what's more, undefined), and N-TiOx dainty films by sputtering have been controlled by analyzing the hues, morphologies, gem structures, nuclear synthesis, electrical resistivity's, and hardness of the films. **[9]**

Cho *et al.* (2012) had published their research on the topic TiNxOy dainty films were kept on Si(100) substrates at 500 C utilizing RF PECVD framework. Titanium isopropoxide was utilized as antecedent with various nitrogen stream rate to control nitrogen substance in the
Films. In this work, we explore the auxiliary property of nitride materials, concentrated on general property of TiOxNy material with nitrogen transition developed by RF PECVD. TiOxNy films were stored by PECVD strategy utilizing titanium isopropoxide antecedent under various nitrogen stream rate. All tests were set up with a steady Ar motion at 100 sccm and substrate temperature at 500 C. **[10]**

Sr No	Resercher s	Substrat e& Films	Coating parameter	Results
1	**Herman *et al.*(**2006)	Si(TiO_XN_Y)	Target Diameter (50mm) Total pressure of sputtering gas (0.5 Pa) Target to substrate distance (100mm) Discharge voltage (418–463V	Water droplet contact angle (20°) Thickness of film (8 nm) UV irradiation λ (365 nm)
2	**Akazawa *et al.*(**2012)	Si(TiO_XN_Y)	RF power (600 W) Microwave power (530 W) Target to substrate distance(18 mm) Temparture of substrate (70°)	Electrical Resistivity ($6*10^{-4}$ to 1Ωcm) 2θ angle of TiO(111) & TiN(111) are (37.3° and 36.8°) Total flow rate (1.4 sccm)
3	**Balaceanu *et al.***(2007)	Si(TiO_XN_Y)	Base pressure in camber ($5*10^{-4}$ Pa) Scratching speed (10mm/min)	Substrate Hardness (61 HRC) Incident angle (60°) Thickness (0.22 to 0.28) Corrosion rate ($1*10^{-3}$ and $1*10^{-2}$ mm/year)
4	**Demeter *et al.***(2016)	metallic (TiO_XN_Y)	Target Diameter (50 mm) Thickness (5 mm) Total pressure (0.85 Pa) Mass flow rate Ar,N_2,O_2 (50,2,0.16 sccm)	Wave length range (200 to 1000 nm) Optical transmittan ce wave length range (300 to 1100 nm) Sequence repetition frequency (400 to 1600 HZ)
5	**Hsieh *et al.*** (2016)	Si(TiO_XN_Y)	Target diameter (50 mm) Target to substrate distance (100mm) RF power (80 watt) Film deposited oxygen flow rate (0.3 sccm)	Highest hardness (25 GPa) Surface energy (40-60 mJ/m^2)

Fabreguette *et al.* (2000) had work on the data of temperature and substrate influence on the structure of TiNxOy thin films grown by low pressure metal organic chemical vapor deposition. The film nitrogen content, acquired by Rutherford backscattering spectroscopy (RBS), increments as the development temperature increments (from 23 at.% at 450°C to 46 at.% at 750°C). Underneath 550°C, the films do not demonstrate any X-beam diffraction design. Above 550°C, the kept films present the (111) and (200) TiN surfaces. Films kept on (100) Si display a 2h move to higher Bragg edges, contingent upon the N/O proportion. In the present investigation, the structure of TiNxOy flimsy films created by LP-MOCVD is portrayed. Titanium oxinitride films acquired by LP-MOCVD were described by XRD, XPS and RBS techniques. **[11]**

Feng *et al.* (2011) had work on the data of Formation and composition of titanium oxinitride nano crystals synthesized via nitridizing titanium oxide for nonvolatile memory applications Arrangement and synthesis examinations of titanium oxinitride nanocrystals (NCs) created through treating a magnetron co-sputtered meager film of titanium and silicon dioxide with a quick warm toughening in nitrogen encompassing were shown for nonvolatile memory applications. This examination researches material investigations and the arrangement of TiNxOy NCs created by co-sputtering titanium and silicon dioxide focuses with various toughening conditions in N2 encompassing. **[12]**

Goupy *et al.* (2013) had work on structure, electrical conductivity, critical superconducting temperature and mechanical properties of TiNxOy thin films. We investigated the auxiliary and mechanical properties of titanium oxynitride meager films TiNxOy. The electrical resistivity also, the basic superconducting temperature were estimated by the four-point test technique. Acoustic and versatile properties were controlled by the pico second ultrasonic and the Brillion light dispersing strategies as an element of the nitrogen fixation. To anticipate the warm protection limits of the multilayers that are possibility for application in aviation captors at low temperature, it is imperative to know well the acoustic properties, the mass thickness and the superconducting change temperature Tc of the materials utilized in the stack **[13]**

Mohamed *et al.* (2004) had work on on Effect of heat treatment on structural, optical and mechanical properties of sputtered TiOxNy films. TiOxNy films were deposited by reactive dc magnetron sputtering at room temperature. The influence of the annealing temperature on the structural, mechanical and optical properties of amorphous TiOxNy films was investigated. The stoichiometry of the example arranged in unadulterated oxygen does not change upon tempering while the stoichiometry of the examples arranged in an oxygen/nitrogen blend changes to TiO2 because of oxidation. **[14]**

Vaz *et al.* (2003) had work on the data of preparation of magnetron sputtered TiN*x*O*y* thin films Inside the edge of this work, r.f. responsive magnetron sputtered TiNxOy films were stored on steel, silicon and glass substrates at a steady temperature of 300 8C. These outcomes demonstrated that past synthesis, microstructure was impacted essentially by the arrangement conditions, specifically particle assault. **[15]**

Vaz *et al.* (2004) had work on Structural, optical and mechanical properties of coloured TiN*x*O*y* thin films Inside the casing of this work, hued films dependent on single layered titanium oxynitride (TiNxOy) mixes were readied. Mulling over this, the fundamental reason for this work comprises on the investigation of the auxiliary, optical and mechanical properties of hued TiNxOy films as a component of gas blend. The basic technique used to set up the examples with various hues together with the generally high hardness esteems and moderate compressive anxieties, lead to the end that one can tailor this effectively arranged Ti– N– O covering framework with shifted shading. **[16]**

Zheng *et al.* (2004) had work on titanium oxynitride (TiOxNy) with differing nitrogen substance collected in the pores of mesoporous material has been accomplished by nitriding titania-altered MCM-41 under streaming NH3 environment. In the present work, the TiOxNy gathered in mesoporous silica MCM-41 were incorporated by the nitridation of titania-altered MCM-41. In outline, titanium oxynitride has been amassed in mesoporous materials out of the blue by nitriding TiO2 inside the pores of MCM-41. **[17]**

Sr No	Resercher s	Substrate & Films	Coating parameter	Results
1	**Martev *et al.***(2002)	Si(TiO_XN_Y)	Base pressure (10^{-6} Pa) Temperatu re of substrate (<100°) Ion energy (3 KeV) Density current (20 μA/cm^2)	Reactive Density range (0.06 to 0.2) Ratio range of Po_2/PN_2 (10^{-2} to 10^{-1}) Partial pressures of nitrogen and oxygen in the range (1*10^{-5} to – 3*10^{-3} Pa)
2	**Pohrelyuk *et al.***(2019)	Si(Ti-6Al-4v alloys)	Tempeture of sputtering (750°-950°) Vacuum pressure (10^{-3} Pa) Partial pressure of	Surface micro hardness (10GPa to 17 GPa) Isothermal expose (5h) Counting time (5sec)

			oxygen (0.001 Pa) Substrate thickness(2μm)	Thickness diffusion layer (40 to 70 μm)
3	**Rawal** ***et al.***(2012)	Si(TiO_XN_Y)	Sputtering pressure (4 to 8 Pa) Base pressure ($4*10^{-4}$ Pa) Deposition temperature (500° C) Target to substrate distance(50 mm)	Deposition time (140 min) Band gap (1.9 to 1.83 Ev) Compression stress (-2.6to -7.2GPa) Contact angle value (107.4°) Maximum surface roughness (12.9 nm)
4	**Rizzo** ***et al.***(2009)	Si(100)(TiNO)	Deposition chamber pressure ($6*10^{-5}$ Pa) Working pressure (3 Pa) Power supply (200 W) Target to substrate distance(50 mm)	Binding energy (2Ev) Particle depth range (7 A°) Displacement energy (22 Ev) Density (5.49 cm^3)
5	**Subramanian** ***et al.***(2011)	Si(TiNO)	Target to substrate distance(60 mm) Operating vacuum($2*10^{-3}$ m Bar) Substrate temperature (400° c) Base pressure (10^{-8} Torr)	Wave length (632.8 nm) Frequencies valve 0.01 to 100 KHz) Corrosion rate (3.1 mm/y) Resistance (14727.7 Ωcm^2)

Balaceanu ***et al.*** (2007) had work on the interest for TiNxOy films has expanded as of late because of their properties reliance on the N/O proportion. Over the previous decade, there was an impressive enthusiasm for the investigation of different transitional oxy-nitride dainty films, due to their momentous optical and electronic properties, mechanical conduct and synthetic solidness. As of late, interest for TiNxOy films has expanded because of the articulated reliance of their properties on the N/O proportion. TiNxOy slight films were acquired by rf PLD and RPM strategies utilizing distinctive proportions of the mass stream rates of the responsive gases. **[18]**

Dong ***et al.*** (2015) had work on the impacts of TiON middle of the road layer on the microstructure and attractive properties of FePt-SiNx-C films were deliberately explored. It is discovered that with utilizing TiON moderate layer, FePt grain disengagement and grain measure consistency were improved. For the investigation of viable applications, it is basic to manufacture FePt films with great (001) surface, a vast opposite magneto-crystalline anisotropy, and little grain measure with a narrow size dissemination. **[19]**

Li ***et al.*** (2019) had chosen TiNx and iNxOy layers were then used to create the multilayered structures. Optical properties were surveyed at room temperature and high temperatures up to 800 °C. In light of the developing need of sustainable power source, one of the one of a kind advances is the age of power utilizing sun powered warm frameworks. Among them, the concentrated sun powered power (CSP) framework speaks to one giving high proficiency of sun oriented radiation gathering. Responsive magnetron sputter stored TiNxOy was explored for use as high temperature, up to 800 °C, sunlight based specific safeguard layers. **[20]**

Barhai ***et al.*** (2010) had work on Titanium nitride and titanium oxynitride films were kept by shifting the plasma current thickness from 10 mA/cm2 to 40 mA/cm2 utilizing DC magnetron sputtering at consistent gas stream rate and testimony time. TiN films because of its hardness, properties of boundary dissemination, stable security and alluring hues have picked up significance in wide scope of uses like cutting apparatuses, MEMS, sun powered reflector and brightening covering and so on. Titanium nitride and titanium oxynitride hued films were set up at various plasma current densities utilizing DC magnetron sputtering framework at a consistent gas flowrate and statement time. **[21]**

3. CONCLUSION

The fields of application of TiO2 films have been continuously expanding. Particular attention has recently been paid to Nb-doped TiO2 films as emerging transparent conductors. The applications of Titanium based coating is extensively expanding because of its exceptional properties. Nitride based ternary thin films like TiAlN, TiVN and TiMoN has great demand in industrial applications, as it gives better film properties like high hardness, low coefficient of friction, good wear resistance and excellent corrosion protection, high melting point etc. as compared to binary nitride compounds.

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