**Structural Tribological Characterization and Mechanical Properties of Ti-Zr-N Coating Deposited By RF/DC Magnetron Sputtering**

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**Abstract**

Ti-Zr-N film was formed by the E19 RF / DC steel vapor deposition magnetron sputtering method (100 W). The composition of the elements and the phases, the nanoureza were examined by SEM, XRD, AFM, corrosion or microhardness. Ti (DC-100W) and Zr (RF-100W), camera pr = 3 x 10 m.bar, evaporated pr = 2 x 10 m.bar, air flow 15 sccm, nitrogen flow 3 sc cm manufactured by splash DC magnetron Much interest has been observed in the characterization of thin films of (Ti-Zr) N. We produce (Ti-Zr) N thin films and in this and in the mechanical, tribological and morphological studies presented. The thin film was prepared by the PVD (physical vapor deposition) method by spraying with an RF / DC magnetron using a titanium-zirconium lens with a purity of 99.99%. A mixture of argon and nitrogen was found for the discharge. The XRD analysis discovered that the Ti-Zr-N coating has high hardness compared to binary nitric acid TiN and ZrN. a rise in hardness is determined by increasing the Zr content. once tempering, however, it absolutely was found that the coating preserved higher hardness stability by reducing the Zr content. The TiN / ZrN multilayer microhardness augmented to 314 GPA at 200 ° C. Exploratory outcomes have demonstrated Improved coating (Ti, Zr) N the consumption opposition of the E19 substrate. The improved erosion obstruction is a result of the nanocomposite structure (Ti-Zr-N), that highlights a thick columnar microstructure that is tight to destructive fluids. Covering coatings (Ti, Zr) N have higher consumption obstruction than higher quality for both temperature levels.

**Keywords:** RF/DC magnetron sputtering, tribology, corrosion resistance, TiN/ZrN

**I. Introduction**

Thin film (Ti-Zr) N studies developed using various technologies over the last decade are of great interest due to their wide range in various fields including
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engineering, electronics, tribology and optics. This is for the most part since they have improved mechanical properties, for example, high oxidation and erosion obstruction, wear opposition and more prominent hardness. Adjust the correlation with the vertical granules to show preferred bias at substrate bias. Even if the substrate is further polarized, the atomic weight relationship between Ti and the portion of the metal element remains almost constant, but the ratio of Na (Ti + Zr) is about 1.1. Composite films have higher stiffness than TiN and ZrN binary films under similar conditions. Deposited films with a polarization of -300 V have the greatest biological load (Lc). [II]

The ternary coatings (Ti, Zr) exhibit greater microhardness compared to binary TiN and ZrN coatings deposited under comparable conditions. A better combination of microhardness and adhesion conditions was obtained at 60% polarization and -70 V of the OEM. Substrate bias is provided by DC energy pulsed by Advanced Energy between 20 and 100 kHz, and the DC bias setting was y-55-y-105V. The distance between the surface of the precision mold target and the substrate is 13 cm. [III] A vacuum arc deposition process affidavit procedure utilizing a plasma consolidating Ti and Zr streams in an \( \text{N}_2 \) environment with different bend current proportions of the cathode Ti and Zr. After the testimony, the examples were strengthened at a temperature of 850 ° C. under vacuum. [V-IV].

This film was created by PAPVD (plasma enhanced physical vapour deposition) innovation utilizing beat circular segment in a solitary evaporator framework utilizing a 99.99% immaculateness titanium-zirconium focal point. An argon-nitrogen blend was utilized for the release. Movies were developed from beat targets comprising of 70% Ti and 30% Zr utilizing the PAPVD heartbeat circular segment strategy. The XP range demonstrated that a strong period of (Ti-Zr) N was framed at all weights. The SPM picture demonstrates a run of the mill grain structure normal for movies developed utilizing PAPVD, where a higher GS was watched for the 4 mbar (M 2) development test. At the most astounding weight tried, the extent of the FC was decreased. [VII]

Applying low doses of argon ions to materials could be a powerful way to study changes in material properties because of radiation damage. The particle bombardment discovered for ternary nitrides will increase and reduces. The primary solid solution shaped by the electron tube co-sputtering of atomic number 22 and zirconium targets in a very nitrogen-argon atmosphere showed higher resistance to radiation (Xe + 18, E = 360 keV, 8 x 10\(^{14}\) compared to binary nitrides) -2 cm ion fluence). This is often mirrored within the behaviour of the stability and resistance properties of their part states. The tendency to modify the nanohardness when bidirectional irradiation is shown at the most within the increase of the ternary coatings of Ti zero.5 Zr 0.5 N and of the decrease of ZrN coatings. Irradiation increased the electric resistance by 400th and caused small additional compression stress (about zero.6 GPa). [VIII]

The multilayer of TiN and ZrN in the perfect world consists of (111) TiN and ZrN layers with three-dimensional structure and orientation. Ti-ZR-N coating. (Ti, Zr) N is (111) and, furthermore, the residual pressure at a variation of y 6 to y 4 GPA bets on the polarization associated with the substrate. As L decreased, the nano-allylicity of the TiNyZrN multilayer increased to 29 GPA, and the modulus decreased to 291 GPA in contrast to the ZrN solid film (25 and 349 GPA separation). The nanohardness of the coating (Ti, Zr) N was 35-40 GPA. [X]

The properties Tantalum nitrate (TaN) multilayer covering by DC Magnetron sputtering at different testimony temperature (200°C and 400°C) were proposed in the examination.
The TaN multilayer coating was stored sequentially with the layers at base weight 3.7x10^-6 m.bar, working weight 11.5x10^-3 m.bar, Ar: N stream rate 15:28 SCCM 100w by DC magnetron sputtering. The impact of microstructure of layer thickness was explored. Higher hardness was found, 200°C covering around 180,188 and 144 GPa separately. The counter consumption conduct was additionally broke down by salt shower and dampness with fog. TaN coating at 200°C helps prevent 100 W of TaN retention film from abrading, making the structure small and making the hardness higher than other information stored. Coating attributes, including surface morphology, hardness and tribological conductivity. [XI]

II. Experimental Procedure

RF/ Dc coating on the substrates E19 is done on the instrument named palsy’s (model no.MP300). Target utilized as a part of sputtering process is titanium and zirconium. Measurements of the target are 2inch dia and 3mm thickness. Coating for the substrates were done under different parameters like chamber base pressure 3x10^-2 m.bar and Working pressure 2x10^-3 m.bar. Temperatures for coating the substrates are 200’c and 400’c. Time taken for covering one substrate is 1 hr at 100w power. Voltage and amperes utilized for covering are 503v and 203A individually. Argon flow rate are embedded amid covering at the proportion of 15sccm (standard cubic centimeter per min) and the nitrogen flow rate are embedded amid covering at the proportion of 3sccm (standard cubic centimeter per min).

Table 1: Atomic concentration of Titanium-Zirconium-nitrogen for the E-19/Ti-Zr-N films deposited at various temperature and same gas intake pressure

| Sample No. | Chamber base pressure (m.bar) | Deposition pressure (m.bar) | Ar flow Rate (sccm) | N2 flow Rate (sccm) | Target to substrate Distance (mm) | Sub. Temp (°c) | Ti Interlayer (min) | Ti (DC) (W) | Zr (RF) (W) |
|------------|-----------------------------|-----------------------------|---------------------|---------------------|----------------------------------|----------------|---------------------|-------------|-------------|
| S1         | 3x10^-6                     | 2x10^-3                     | 15                  | 3                   | 70                               | 200            | 5                   | 100         | 100         |
| S2         | 3x10^-6                     | 2x10^-3                     | 15                  | 3                   | 70                               | 400            | 5                   | 100         | 100         |

III. Result and Discussion

III.i. Atomic Force Microscopy (AFM)

The surface morphology of the movies was researched with AFM in the non-contact mode utilizing a silicon nitride cantilever. The nuclear power pictures demonstrate the adjustment in the morphology of the film with the adjustment in the temperature. The titanium zirconium nitride film saved at 200°c shows harsh sporadic structure, while, the AFM picture of titanium zirconium nitride film saved at 400°c shows litter surface highlights, joined with an expansion in the harshness (Ra) of the film (i.e. 3.222 nm to 2.951 nm). The Ti2p and Zr peaks are replicas of turn orbitals isolated by Ti2p and Zr3d, individually. Inner and outer parameters can communicate superficially and in most strong ointments, in this manner influencing the estimation of the coefficient of grinding.
The accompanying ends demonstrate that the microstructure of the covering is subject to the preparing conditions.

![Surface topography 3D view of samples obtained by AFM](image)

**Fig. 1** Surface topography 3D view of samples obtained by AFM (A),(B) sample coated at 200°c, (C),(D)sample coated at 400°c

In this profile which we have taken from the 200°c of Ti-Zr-N covered. Example we have noticed the roughness values of Ti-Zr-N at the different parameters at different place of the material at the different values of the parameters. The roughness value is 3.222nm. (Ref.Fig.2) and 2.951nm for 400°c (Fig.3)
III.ii. Scanning Electron Microscope (SEM)

The current deposited at various percentages of the cathode is current, and an increase in total plasma flow density results in an increase in columnar particle size, indicating that it reaches 100 nm or less. For comparison, the use of titanium plasma flow causes the formation of a TiN coating with typical columnar particles. The CAVD process is characterized by the formation of a highly ionized low-temperature plasma flow. The presence of collisional ion droplet phases of Ti and Zr ions from the energy of the metal cathode reaches titanium-zirconium at 200 °C. This phase observed on the N coating consists mainly of titanium and zirconium components and is covered with a thin layer of nitride. It should be noted that the diffraction peaks of the film deposited with a bias of 500 V spread and split. This indicates that multiphase structure types, namely ZrN phase with binary tin phase and ternary TiZrN phase can be simultaneously present in the coating. The distribution of Ti and Zr ions from one target to another is not uniform.(ref.Fig.4)
The indentation and discharge stages (30 mN) were performed under load control. The adjacent indent were separated by at least 50µm. combined the consequence of AFM picture the Ti-Zr-N film critical expand the hardness of the substrates, which can be the purpose behind the better cell attachment on Ti-Zr-N gathering.

Fig. 4 SEM images of sample coated at 200°C.
III.iii. X-ray Diffraction (XRD)

X-ray diffraction of the 200°c (ref.Fig.6) of the different parameters of the data range 20°-59.983° and the wavelength is 1.540598Å. Full width at half maximum (FWHM) at 20 is 36.72° and the full width at half maximum (FWHM) is 0.4047 and I/Io is 143.31. Rp is calculated pattern Rp=72.4% and (200) simple cubic present at 45°c can have a multiple-atom basic. The atom at the center of the cell
would create a diffraction at the (200) plane. The plane of interest at two of the crystallographic axes (1, 1, ∞), (110) at 26°(2θ). X-ray diffraction patterns of the Ti-Zr-N coating are reported after coating. It has been found that the growth films consist of a simple cubic Ti-Zr-N structure. Space group I 4/ mm (139) and the crystal system is tetragonal, cell parameters a=4.01900 Å and c = 9.57700 Å and the physical properties of the cal. density is 6.82200 g/cm³.

For 400°c (ref. Fig.7) of the different parameters of the data range is 20°-59.983° and the wavelength is 1.541874 Å. Full width at half maximum (FWHM) is 0.4047 and the 2θ value is 36.72 and I/Io is 157.10. Rp is calculated pattern Rp = 3.3% and (200) simple cubic present at 45° can have a multiple-atom basis. The atom at the center of the cell would create a diffraction at the (200) plane. The plane of the interest acts two of the crystallographic axes (1, 1, ∞) (110) at the 26°(2θ). The phase is Ti-Zr-N and the space group is Fm’m (225) and the crystal system is cubic. The cell parameters a = 4.43400 Å.
III. iv. Corrosion Test with Salt Spray

Corrosion tests at various parameters like temperature of solution 35°C +/- 2°C, the pH of the salt solution 3.1-3.3 for collection of solution per hour 1.0-2.0 ml. The pressure of compressed air 70-170kpa and the concentration sodium chloride (5%NaCl solution + acetic acid to maintain pH between 3.1 to 3.3) is 50g/l +/- 5g/l. Afterwards dried promptly after this no consumption happened until 12 hours so the introduction timeframe expanded to 24 hours then red rust noticed.

Table – 2 Corrosion (salt spray) test observations for 200°C

| SL.No | Time   | Observation               |
|-------|--------|---------------------------|
| 1     | At 12 Hrs | No corrosion              |
| 2     | At 24 Hrs | Red corrosion observed    |

III. v. Corrosion Test with Humidity

In this sort of corrosion, the humidity was noted as 95% by hygrometer amid the test. The temperature of the test showed 45°C. The weight of air for atomizing was 2-3 bars consistently by a weight controller.

Observation of sample surfaces:

The surface conditions of the covered example were watched and derivations were observed. There is no sign of deterioration and no rust noticed up to 24 hours.

IV. Results:

| Characteristics Test                                      | Result                                      |
|-----------------------------------------------------------|---------------------------------------------|
| Humidity test @ 45°C & 95% RH for 24hrs                    | No sign of deterioration and no rust noticed up to 24hrs |
V. Conclusion

I have shown using real time measurements during RF/DC magnetron sputtering, combine ternary Ti-Zr-N coatings Ti & Zr target 99% purity. The roughness of the films is 3.222nm at 200˚c and 2.951nm at 400˚c independently. It is the obvious from the AFM micrographs that roughness decreases with increases in temperature of the covering. Titanium-ZR-N coatings on E19 substrates have better corrosion resistance than low carbon steel coatings. The consumption opposition of covered titanium (Ti-Zr-N) on E19 substrate is higher than that of TiN layer and structure of the nanocomposite (TiN) coating with corrosion and the coating (Ti-Zr-Zr) itself is not it. It is transparent. There is almost no corrosion current. Phenomenal corrosion resistance and a slight increment of E19 substrate. The Ti-Zr-N coating has a columnar microstructure with a preferred orientation (200) for a 200˚c sample and (110) for the 400˚c sample with a simple cubic structure. The ratio between RP and RS for the demonstration of the corresponding sample that the deposition of (Ti-Zr-N) for 200˚c and 400˚c (RP = 72.4% and RP = 3.3%). The highest microhardness value of about 314 Gpa correspondingly to 200˚c. It has been found that the mechanical properties of the films are procured at ordinary substrate temperatures.

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