Data Article

Dataset on microstructural, structural and tribology characterization of TiC thin film on CpTi substrate grown by RF magnetron sputtering

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A B S T R A C T

The datasets in this article are supplementary to the corresponding research article [1, 2]. The planar morphology and topography of TiC thin films coated on commercially pure Titanium (CpTi) grown by RF magnetron sputtering were investigated using Field emission scanning electron microscope (FESEM) and Atomic force microscope (AFM). The mechanical properties such as Hardness and Young Modulus of the thin film coating was studied using Nanohardness. Furthermore, grazing incidence X-ray diffractometer (GIXRD) and Raman spectroscopy were used to analyse the structural and composition of the TiC thin film coating.

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1. Data description

The RF magnetron sputtering process parameters develop by using L9 Taguchi orthogonal array is presented in Table 1. The Raman spectra of the TiC thin film coatings obtained from Raman spectroscopy is presented in Fig. 1. The GIXRD diffractogram of the structural properties is shown in Fig. 2 and the GIXRD parameters of the TiC thin film coatings such as crystalline size, dislocation density, microstrain and texture coefficient are tabulated in Table 2. Fig. 3 illustrates the planar microstructural morphology evolution of the TiC thin film coating obtained from FESEM analysis while the surface topography result from the AFM analysis is presented in Fig. 4. The AFM statistical information about the surface topography such as mean roughness, skewness and kurtosis are tabulated in Fig. 4 (see Table 3). The output response and plots of the load against displacement are tabulated in Table 4. The plot of the sample numbers against the young modulus and hardness is presented in Fig. 5.

### Specification Table

| Subject | Surfaces, Coatings and Films |
|---------|-----------------------------|
| Specific subject area | RF Magnetron sputtering coating and nanomaterial thin film characterizations. |
| Type of data | Table |
| Image |
| Figure |
| How data were acquired | • ZEISS Gemini*2 Field emission scanning electron microscope (FESEM), IIT, Kharagpur, India. |
| • Hysitron Triboindenter T1950 Nanohardness, IIT Kharagpur, India |
| • VEECO Atomic force microscope (AFM) Wits University, South Africa |
| • PANalytical's Xpert Pro Grazing incidence X-ray diffractometer (GIXRD), India. |
| • Alpha 300R WITEC Raman spectroscopy, University of Johannesburg, South Africa. |
| Data format | Analysed |
| Parameters for data collection | The CpTi substrates were polished and ground using ASTM standard. Further cleansing in acetone, isopropanol and deionized water were performed |
| Pre-sputtering for 5 mins to remove contaminants |
| Description of data collected | The FESEM images were captured on the microscope using the ZEISS software at a magnification of X50000 |
| The AFM images of the height profile were captured using nanoscope software |
| The indentation depth of the nanohardness was 10% of the film thickness and the load control mode was used. |
| The Raman was conducted in ambient conduction at an integration time of 10 seconds. |
| The GIXRD was done at an angle of 0.02° from 10° to 90° |
| Data source location | India Institute of Technology, Kharagpur, India |
| University of Witwatersrand, Johannesburg, South Africa |
| University of Johannesburg, Johannesburg, South Africa |
| Data accessibility | Data are available on a public repository |
| Repository name: Mendeley Data |
| https://doi.org/10.17632/c25mgp6ptz.1 |
| Related research article | O.O. Abegunde, E.T Akinlabi and O.P Oladijo, “GIXRD, Raman and Surface analysis of TiC thin film coating produced by RF magnetron sputtering,” in Journal of Physics: Conference Series, 2019. |
| O.O. Abegunde, E.T Akinlabi and O.P Oladijo and J. D. Majumdar, “Surface Integrity of TiC Thin Film Produced by RF Magnetron Sputtering,” Procedia Manufacturing, 2019. |

### Value of Data

- The data provide an insight into the significance and influence of thin film coatings on properties of metals.
- These data can be used for research applications and industrial usage in the area of surface coatings, materials application and mechanical engineering.
- The data is applicable for the development of predictive and mathematical models for optimization of RF process parameters.
- The data presents the effect of RF magnetron sputtering process parameters on the coating properties.
- The data can be explored by scientists and researchers in the field of materials and mechanical engineering.
Table 1
Experimental matrix for deposition.

| S/N | L1 | L2 | L3 | L4 | L5 | L6 | L7 | L8 | L9 |
|-----|----|----|----|----|----|----|----|----|----|
| Power (W) | 150 | 150 | 150 | 200 | 200 | 200 | 250 | 250 | 250 |
| Time (Hrs) | 2.0 | 2.5 | 3.0 | 2.0 | 2.5 | 3.0 | 2.0 | 2.5 | 3.0 |
| Temperature (°C) | 80 | 90 | 100 | 90 | 100 | 80 | 100 | 80 | 90 |

Fig. 1. Raman Spectra of TiC thin film coatings.

Fig. 2. GIXRD diffractogram of the TiC thin film coating.
Table 2
GIXRD output data for CrTi/TiC thin film Coatings.

| Experimental run | \(2\theta (^\circ)\) | d spacing (Å) | D ASTM (Å) | FWHM (\(^\circ\)) (hkl) | Crystalline size (nm) | Dislocation density (lines/m²) \(\times 10^{14}\) | Micro strain \((\varepsilon) \times 10^{-4}\) | Texture coefficient |
|------------------|---------------------|---------------|------------|--------------------------|----------------------|--------------------------------|-------------------------|---------------------|
| L2               | 38.3091 2.3476      | 2.499         | 0.1092     | 110 77.0                 | 1.6860               | 4.5010                   | 8.67                    |                     |
|                  | 40.0757 2.2481      | 2.1637        | 0.2184     | 200 38.72                | 6.6705               | 8.9526                   | 2.40                    |                     |
|                  | 52.9020 1.7293      | 1.5302        | 0.1404     | 220 63.20                | 2.5037               | 5.4848                   | 0.90                    |                     |
|                  | 70.5517 1.3338      | 1.3047        | 0.0936     | 311 103.96               | 0.9252               | 3.33412                  | 3.40                    |                     |
| L3               | 38.4336 2.3403      | 2.499         | 0.1404     | 110 59.92                | 2.7850               | 5.7848                   | 8.31                    |                     |
|                  | 40.2095 2.2410      | 2.1637        | 0.1872     | 200 45.19                | 4.8966               | 7.6704                   | 2.56                    |                     |
|                  | 53.0352 1.7253      | 1.5302        | 0.156      | 220 56.91                | 3.0874               | 6.0907                   | 0.98                    |                     |
|                  | 70.9740 1.3318      | 1.3047        | 0.1092     | 311 89.29                | 1.2543               | 3.8821                   | 3.65                    |                     |
| L4               | 38.3424 2.3457      | 2.499         | 0.1248     | 110 67.39                | 2.2017               | 5.1434                   | 8.73                    |                     |
|                  | 40.1102 2.2463      | 2.1637        | 0.234      | 200 36.14                | 7.6558               | 9.5911                   | 2.23                    |                     |
|                  | 52.9374 1.7283      | 1.5302        | 0.1092     | 220 81.27                | 1.5141               | 4.2653                   | 1.00                    |                     |
|                  | 70.5817 1.3333      | 1.3047        | 0.1092     | 311 89.13                | 1.2588               | 3.8891                   | 3.58                    |                     |
| L5               | 38.2852 2.3510      | 2.499         | 0.1919     | 110 43.82                | 5.2075               | 7.9102                   | 7.17                    |                     |
|                  | 39.9825 2.255       | 2.1637        | 0.255      | 200 33.05                | 9.1561               | 10.4889                  | 3.44                    |                     |
|                  | 52.823 1.733        | 1.5302        | 0.102      | 220 86.71                | 1.33011              | 3.9978                   | 1.15                    |                     |
|                  | 70.484 1.334        | 1.3047        | 0.171      | 311 56.68                | 3.1122               | 6.1152                   | 3.31                    |                     |
| L8               | 38.3539 2.3469      | 2.499         | 0.2175     | 110 38.67                | 6.6868               | 8.9636                   | 7.10                    |                     |
|                  | 40.075 2.245        | 2.1637        | 0.24      | 200 34.80                | 8.2578               | 9.9610                   | 3.49                    |                     |
|                  | 52.9069 1.7306      | 1.5302        | 0.1023     | 220 86.74                | 1.3292               | 3.9963                   | 1.17                    |                     |
|                  | 70.5457 1.3339      | 1.3047        | 0.156      | 311 62.38                | 2.5701               | 5.5571                   | 3.31                    |                     |
| L9               | 38.4632 2.3385      | 2.499         | 0.1404     | 110 59.93                | 2.7845               | 5.7842                   | 7.80                    |                     |
|                  | 40.2185 2.2404      | 2.1637        | 0.2184     | 200 38.74                | 6.6644               | 8.9486                   | 2.97                    |                     |
|                  | 53.0506 1.7248      | 1.5302        | 0.1092     | 220 81.31                | 1.5126               | 4.2632                   | 1.03                    |                     |
|                  | 70.6954 1.3314      | 1.3047        | 0.1248     | 311 78.04                | 1.6419               | 4.4416                   | 3.50                    |                     |

Fig. 3. Planar view of the microstructural morphology.
2. Experimental design, materials and methods

2.1. Deposition of TiC thin film on CpTi using RF magnetron sputtering

TiC thin films were deposited in an RF Magnetron sputtering on CpTi substrate under different process parameters. The purity of the stoichiometric TiC target used is 99.99% pure TiC. The process parameters varied for the deposition processes were deposition time, power and temperature. An L9 (3^3) experimental array shown in Table 1 was used with three factors at three levels of Low, Mid and High and a total of nine deposition runs were done. Detailed analysis of the deposition condition can be found in Refs. [1,2].

2.2. Microstructural and topography characterization

Atomic force microscopy (Veeco Di2100 AFM) was used to evaluate the 3D surface topographies of the samples. Image scan size of 5 × 5 μm^2 was obtained in tapping mode. All analysis was performed in ambient temperature. Nanoscope software was used for capturing and analyzing the images from the surface of the samples. Field Emission Scanning Electron Microscope FESEM (ZEISS Gemini*2, Germany) capable of capturing nanoscale images effortlessly at very high magnification was used to

Table 3
AFM images of the thin film taken at 5 × 5 μm^2 with Statistical detail.

| S/N | Z-range (nm) | RMS (nm) | Mean Roughness (nm) | Skewness | Kurtosis |
|-----|--------------|----------|---------------------|----------|----------|
| L1  | 252          | 28.830   | 18.34               | 0.41     | 3.342    |
| L2  | 397.25       | 51.593   | 39.684              | 0.263    | 3.898    |
| L3  | 320.68       | 47.506   | 36.906              | 0.611    | 3.807    |
| L4  | 268.35       | 30.579   | 20.482              | 0.646    | 4.316    |
| L5  | 823.89       | 34.56    | 24.734              | 0.536    | 4.081    |
| L6  | 537.62       | 30.72    | 25.632              | 0.159    | 2.307    |
| L7  | 194.85       | 57.197   | 41.392              | 0.09     | 3.110    |
| L8  | 44.66        | 53.467   | 40.330              | 0.451    | 4.223    |
| L9  | 232.99       | 57.837   | 41.570              | 0.970    | 4.408    |
Table 4
Hardness and Young Modulus at different Process Parameters.

| S/N | The plot of Load against displacement | Nanohardness Statistical Parameters |
|-----|--------------------------------------|-------------------------------------|
| L1  | ![Load vs. displacement plot](image1.png) | Young Modulus (GPa) = 157.81  
Hardness (GPa) = 8.01  
Wear resistance = 0.02  
Plasticity index = 0.051  
H_{max} = 28.32  
H_f = 11.73  
% Recovery = 58.58  
Plasticity = 41.42 |
| L2  | ![Load vs. displacement plot](image2.png) | Young Modulus (GPa) = 183.12  
Hardness (GPa) = 8.96  
Wear resistance = 0.02  
Plasticity index = 0.049  
H_{max} = 25.99  
H_f = 11.09  
% Recovery = 57.34  
Plasticity = 42.66 |
| L3  | ![Load vs. displacement plot](image3.png) | Young Modulus (GPa) = 154.06  
Hardness (GPa) = 7.77  
Wear resistance = 0.02  
Plasticity index = 0.050  
H_{max} = 28.94  
H_f = 13.81  
% Recovery = 52.27  
Plasticity = 47.73 |
Table 4 (continued)

| S/N | The plot of Load against displacement | Nanohardness Statistical Parameters |
|-----|---------------------------------------|------------------------------------|
| L4  | ![Graph L4](image1)                    | Young Modulus (GPa) – 115.55       |
|     |                                       | Hardness (GPa) – 4.77              |
|     |                                       | Wear resistance – 0.0081           |
|     |                                       | Plasticity index – 0.041           |
|     |                                       | H_{\text{max}} – 37.89             |
|     |                                       | H_f – 15.20                       |
|     |                                       | % Recovery – 59.89                 |
|     |                                       | Plasticity – 40.11                 |
| L5  | ![Graph L5](image2)                    | Young Modulus (GPa) – 143.99       |
|     |                                       | Hardness (GPa) – 4.96              |
|     |                                       | Wear resistance – 0.0059           |
|     |                                       | Plasticity index – 0.034           |
|     |                                       | H_{\text{max}} – 35.62             |
|     |                                       | H_f – 21.26                       |
|     |                                       | % Recovery – 40.33                 |
|     |                                       | Plasticity – 59.67                 |
| L6  | ![Graph L6](image3)                    | Young Modulus (GPa) – 119.11       |
|     |                                       | Hardness (GPa) – 5.75              |
|     |                                       | Wear resistance – 0.013            |
|     |                                       | Plasticity index – 0.048           |
|     |                                       | H_{\text{max}} – 35.07             |
|     |                                       | H_f – 13.03                       |
|     |                                       | % Recovery – 62.83                 |
|     |                                       | Plasticity – 37.17                 |

(continued on next page)
Table 4 (continued)

| S/N | The plot of Load against displacement | Nanohardness Statistical Parameters |
|-----|--------------------------------------|------------------------------------|
| L7  | ![Plot L7](image1.png) | Young Modulus (GPa) – 159.46
Hardness (GPa) – 9.28
Wear resistance – 0.031
Plasticity index – 0.058
Hmax – 26.38
Hf – 10.86
% Recovery – 58.82
Plasticity – 41.18 |
| L8  | ![Plot L8](image2.png) | Young Modulus (GPa) – 163.41
Hardness (GPa) – 9.19
Wear resistance – 0.030
Plasticity index – 0.056
Hmax – 29.70
Hf – 13.98
% Recovery – 52.95
Plasticity – 47.05 |
| L9  | ![Plot L9](image3.png) | Young Modulus (GPa) – 145.08
Hardness (GPa) – 10.13
Wear resistance – 0.050
Plasticity index – 0.070
Hmax – 26.91
Hf – 7.96
% Recovery – 70.41
Plasticity – 29.59 |
observe the surface morphology evolution. The FESEM can take images at very high magnification and images were taken at 50,000x magnification.

2.3. Structural and composition characterization

Raman analyses were carried out on TiC thin films using an alpha300R (WTec) confocal laser Raman microscope configured with a frequency-doubled Nd-YAG laser (wavelength 532 nm). Raman spectra were collected using ×50 Nikon objectives. A laser power of 2 mW at room temperature was used to prevent burning of the film surface. Beam centring and Raman spectra calibration were performed before spectral acquisition using a-Si standard (111). The Raman spectrum of the substrate was obtained and used to compare with the TiC thin films deposited. Grazing Incidence X-ray Diffractometer (GIXRD PANalytical’s Xpert Pro with Cu K-alpha and wavelength 1.540598 Å) at a very low angle of incidence of 0.02°/s from 10° to 90° was used to study the structural properties of the thin film. The crystallite size (D) was calculated using the Scherer equation, \[ D = \frac{(0.9 \lambda)}{b \cos \theta}; \] where \( \lambda \) is the wavelength of the X-ray used (1.540598 Å); \( b \), the full width at half maximum (FWHM) of the highest-intense peak; and \( \theta \), the Bragg angle.

2.4. Mechanical characterization

Nanomechanical properties such as Young’s modulus and hardness of thin films were obtained by nanoindentation technique (Hysitron, Triboindenter TI950, USA). Load controlled indentation testing followed a trapezoidal (loading-dwelling-unloading) profile with a hold time of typically 15 s at peak load. The peak load was 300μN at a loading rate of 10 μN s⁻¹. The diamond indenter was a Berkovich tip with a tip radius of curvature of 100 nm. From the analyzed load-displacement curves, Young’s modulus of measured films can be calculated using Oliver and Pharr analysis [3,4]. All the data presented in this study corresponds to an average of 10 measurements. The indentation depth was never deeper than 10% of the total coating thickness to avoid the influence of the substrate on the coating [5].

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dib.2020.105205.

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