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Effect of Aluminum Doping on the Microstructure and Adhesion of TiN Thin Films Deposited on Ti-6Al-4V

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Introduction

TiN coatings are used to improve the surface performance of metallic components. Aluminum incorporation can modify their microstructure and mechanical behavior, making its influence on coating adhesion important to understand. This study investigates Al-doped TiN thin films deposited by magnetron sputtering on Ti-6Al-4V and silicon substrates, examining how aluminum content relates to crystalline structure, morphology, thickness, and scratch-induced failure.

Objectives

Aim

To assess how aluminum incorporation affects the structure, morphology and adhesion of TiN films deposited on Ti-6Al-4V by reactive magnetron sputtering.

Specific objectives

- Deposit TiN and TiAlN films varying only the RF power on the Al target (0–200 W).
- Characterize the films by XRD and scratch test.
- Identify the Al target power that gives the best adhesion to the substrate.

Methodology

Table 1. Deposition parameters

Sample	Al target power (RF)
A01	—
A02	200 W
A03	150 W
A04	100 W
A05	50 W

Fixed conditions:

- Ti in DC mode, 200 W;
- Ar/N_2 = 35/15 sccm;
- Working pressure 3 mTorr;
- Deposition time 40 min.

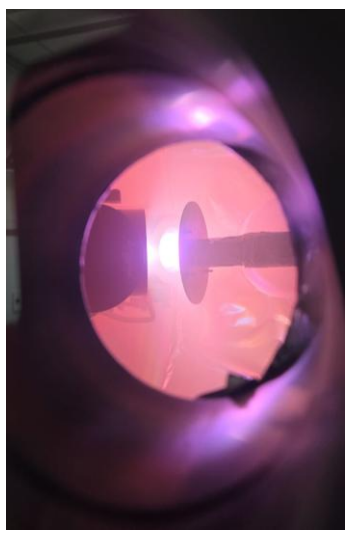


Figure 1. Deposition of TiAlN films.

Results and discussion

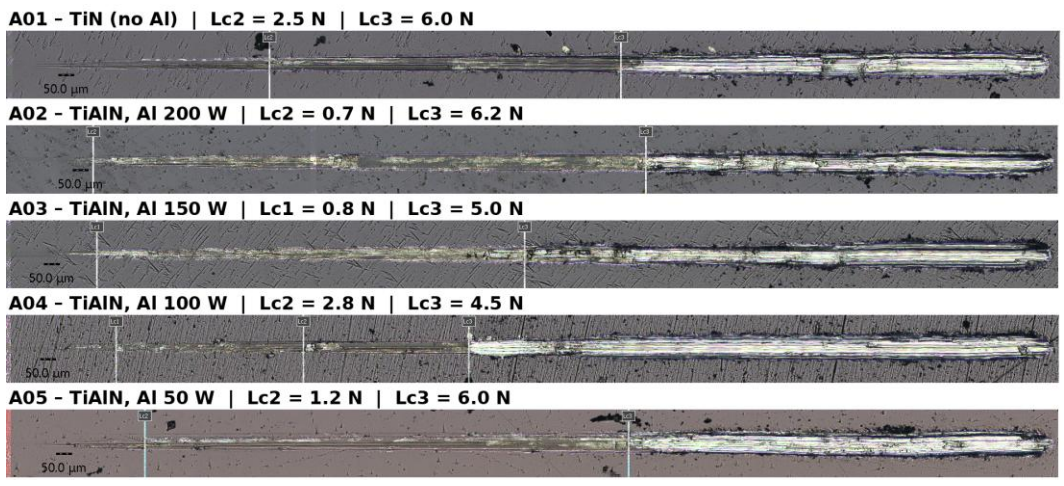


Figure 2. Scratch tracks (0.03–10 N over 3 mm, Rockwell tip R = 100 µm, load increasing left to right). Lc markers as determined from the optical track and friction signal.

Generalized degradation (Lc3) occurred between 4.5 and 6.2 N for all films, with no trend with Al target power. Substrate exposure (Lc2) started earlier in most TiAlN films (0.7–1.2 N) than in TiN (2.5 N), except at 100 W (2.8 N).

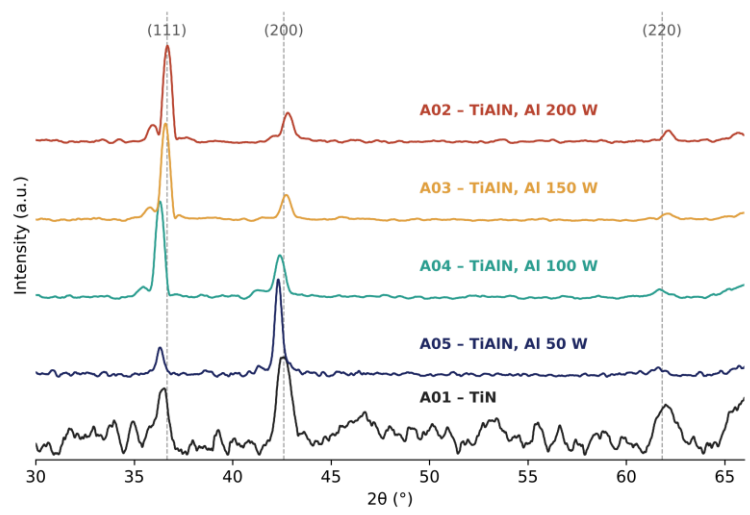


Figure 2. Normalized XRD patterns of the films on Si. Dashed lines: cubic TiN (JCPDS 38-1420).

Conclusions

- Al incorporation did not reduce the load for generalized failure.
- TiAlN films exposed the substrate earlier, indicating a change in failure mode.
- No Al power stood out; 50 and 200 W matched TiN.
- All films were single-phase cubic (Ti,Al)N up to 200 W on the Al target; only the 50 W film changed from (111) to (200) orientation.

References and Acknowledgments

DANIŞMAN, Ş.; ODABAŞ, D.; TEBER, M. The effect of TiN, TiAlN, TiCN thin films obtained by reactive magnetron sputtering method on the wear behavior of Ti6Al4V alloy: a comparative study. *Coatings*, v. 12, n. 9, 1238, 2022.
GHIO, E.; BONILAURI, M. F.; BOLELLI, G.; COLOMBI, P.; CERRI, E. A novel approach to Rockwell and scratch adhesion tests for hard coatings deposited onto Ti6Al4V substrates. *Metals*, v. 15, n. 9, 994, 2025.
DIAS, I. L.; DE OLIVEIRA, P. R. A.; REZENDE, R. L.; SABINO, L. F. S.; DAMASCENO, I. Z.; STAVALE JUNIOR, F. L.; TENTARDINI, E. K. $Ti_{1-x}Al_xN$ or TiN + AlN: an investigation about Al influence on titanium aluminum nitride thin films structural organization. *Ceramics International*, v. 51, n. 2, p. 1813–1820, 2025.

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