INFLUENCE OF INTERSTITIAL OXYGEN AND NITROGEN ON THE TRIBOLOGICAL BEHAVIOUR OF TITANIUM AND TI6AL4V

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KEYWORDS

Surface topography; Friction; Experiments in tribology, Laser surface modification

ABSTRACT

Titanium and its alloys, including Ti6Al4V, have attracted interest from various industries due to their strong mechanical properties and biocompatibility. However, they have poor tribological characteristics. Laser surface modification shows promising way of improving the tribological properties of both titanium and Ti6Al4V [1]. The tribological characteristics of Ti and Ti6Al4V are influenced by the presence and evolution of α and β phases, which are adjusted to fulfil the demands of crucial tribological applications in aerospace and biomedical fields. Depending on the ambient conditions during the laser surface modification, Ti and Ti6Al4V undergo distinct microstructural changes. When the surface is melted with laser, atoms such as oxygen or nitrogen occupy interstitial sites in the lattice of Ti and Ti6Al4V, resulting in varied microstructural transformations due to rapid cooling and martensitic transformation [2-4].

In the present study, the surfaces of Ti and Ti6Al4V were subjected to melting under various ambient environments (Air, N_2, Ar) using a nanosecond laser. Following the melting process, a smoothing operation was carried out using the laser in the presence of Ar to render the samples viable for tribotesting. The microstructural evolution and the tribological characteristics of various samples were studied under grease-lubricated reciprocating sliding conditions. The Ti and Ti6Al4V samples modified in the presence of air showed lower average coefficient of friction and wear rates compared to the other samples. The microstructural transformations due to laser surface modification were studied by FIB machining the cross-section of the worn surface. In addition, large-scale molecular dynamics simulations [5] of scratching were carried out on simplified polycrystalline Ti alloy systems to shed light on the microstructural phenomena occurring during tribological interactions. Changes in microstructure due to the melting process as well as tribo-induced phase transitions could be reproduced and analysed.

ACKNOWLEDGMENTS

SJE acknowledges the Austrian COMET program (Project K2 InTribology1&2, nos. 872176 and 906860).

REFERENCES

[1] Wang DW, Zhou YH, Shen J, Liu Y, Li DF, Zhou Q, Sha G, Xu P, Ebel T, Yan M. *Materials Science and Engineering: A*, 2019 , Aug 5;762:138078.
[2] Kümmel D, Hamann-Schroer M, Hetzner H, Schneider J *Wear*, 2019, 422, 261-268.
[3] Kümmel D, Linsler D, Schneider R, Schneider J *Tribology International*, 2020, 150, 106376.
[4] Wang C, Li J, Wang T, Chai L, Deng C, Wang Y Surface *Coatings and technology*, 2021, 416, 127137.
[5] Eder, S. J., Cihak-Bayr, U., Gachot, C., Rodríguez Ripoll, M. *ACS Applied Materials & Interfaces*, 2018, 10, 24288.