Surface Engineering of Ti6Al4V Firewater Valves for the World's Largest Spar Gas Platform

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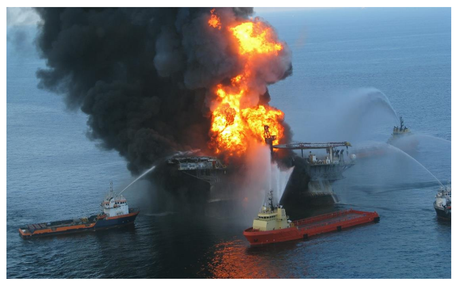
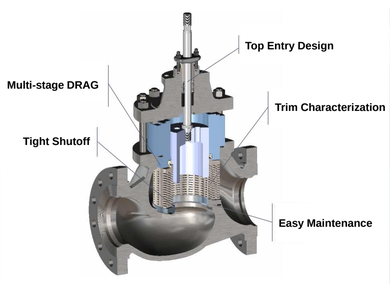
Motivation

- **Safety:** The innovation of unique titanium valves is part of the industry's effort to ensure the highest safety levels for newly developed offshore floating platforms
- **Extended service lifetime:** Titanium is immune to corrosion and, therefore, the extended service lifetime and reduced maintenance combined with enhanced safety provides further crucial benefits
- **Low weight:** Titanium reduces the installation weight by half which is an important factor for offshore floating platforms
- **Poor tribological properties**: Titanium and its alloys are materials with excellent corrosion resistant properties, but under sliding contact exhibit poor wear and friction performance



https://en.wikipedia.org/wiki/Deepwater_Horizon_oil_spill



Courtesy of IMI CCI

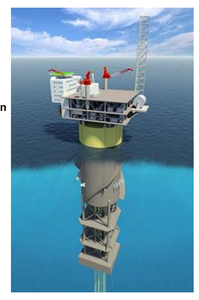


Fig. 1: Deepwater Horizon oil spill (left), CCI valve (middle); the world's largest offshore spar platform – Aasta Hansteen (right)

Surface treatments

Various surface engineering technologies have been applied to Ti6Al4V substrates in order to enhance their tribocorrosion performance in artificial seawater

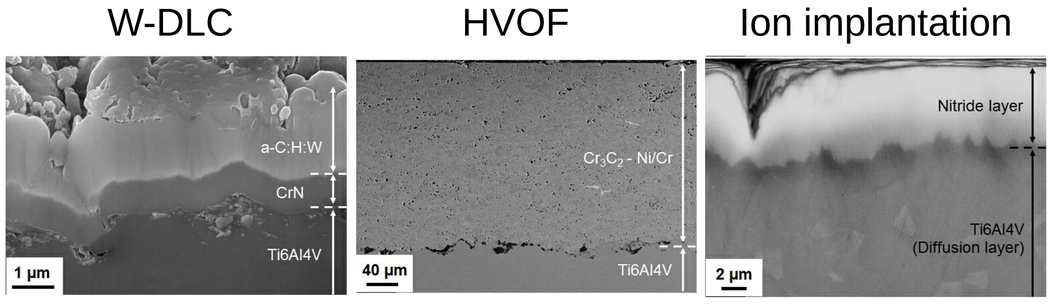


Fig. 2: SEM cross-sectional micrographs of W-DLC (left), HVOF (middle) and Ion implantation treated Ti6Al4V substrate (right) [1]

Tribocorrosion experiments

- **Environment:** Synthetic seawater (NaCl 2.5 wt% and pH = 7.6) prepared according to the ASTM Standard D1141-13
- **Potentiodynamic polarization:** Cathodic cleaning at -1.2 V (5 min); OCP (30 min); potential scan -1.2 V to +1.2 V at 1mV/s
- **Tribocorrosion:** Cathodic cleaning at -1.2 V (5 min); OCP before rubbing (133 min); rubbing at OCP (22 min) and OCP after rubbing (30 min) [1-3]

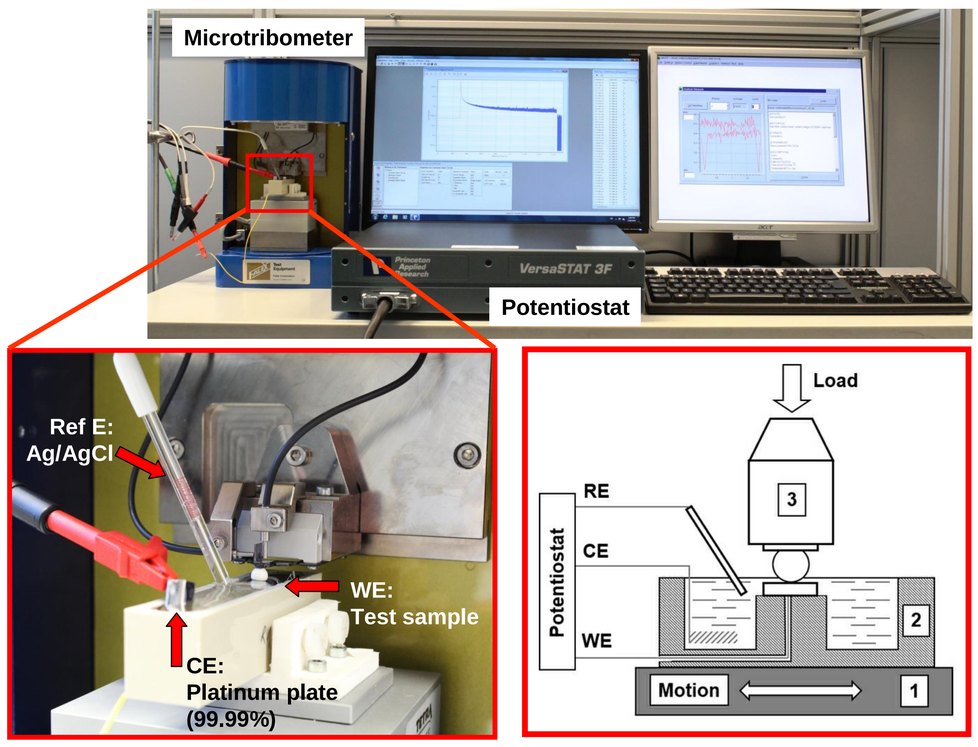


Fig. 3: Electrochemical cell with three electrode setup for the tribocorrosion experiments: working electrode (WE); reference electrode (RE) and Counter electrode (CE) [1]

Summary & Conclusions

- Ion implantation treated Ti6Al4V substrate exhibited the best static corrosion resistance among all the samples

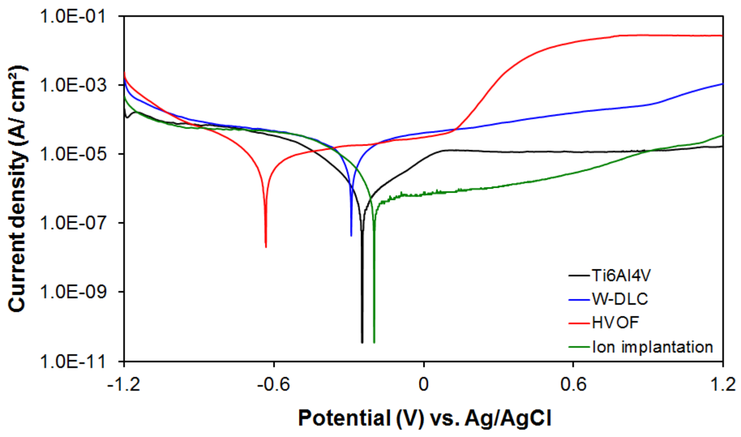


Fig. 4: Potentiodynamic polarization curves of all samples tested in artificial seawater

- Outstanding tribocorrosion performance of W-DLC coating by formation of a low shear strength transfer layer at the sliding interface
- Hydration of HVOF coating led to formation of chromium oxides that improved its frictional characteristics in artificial seawater
- Nitriding the titanium alloy enhanced its tribocorrosion properties in artificial sea water

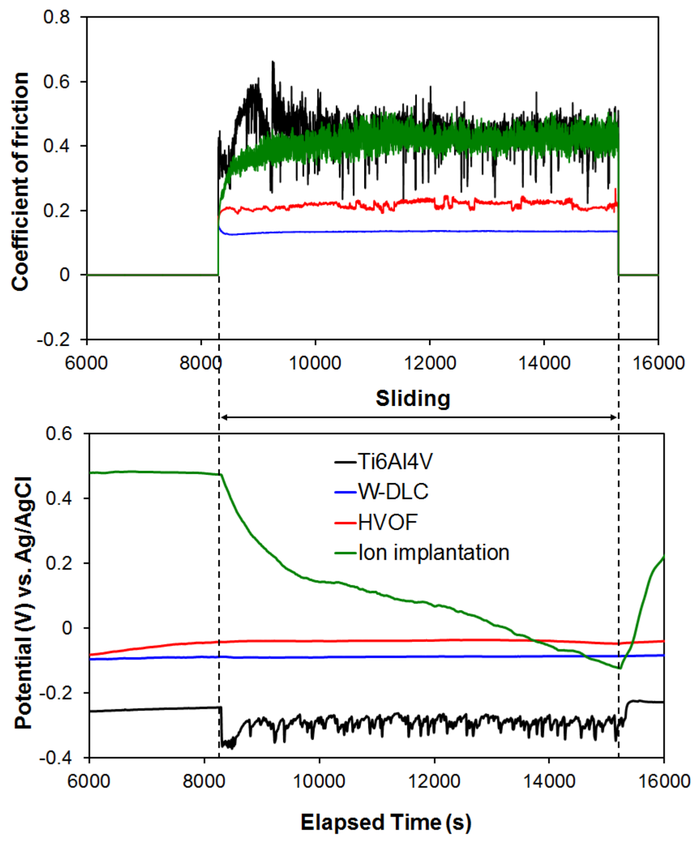


Fig. 5: Evolution of friction and OCP recorded in-situ before, during and after sliding in artificial seawater

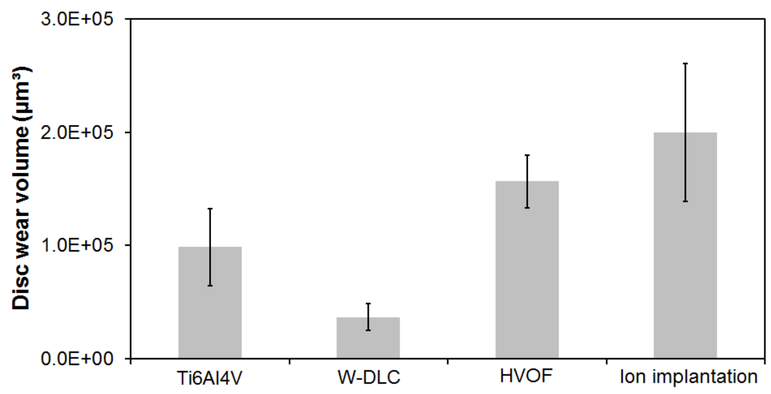


Fig. 6: Average wear volume loss for all the tested samples

Literature of the authors

[1] Totolin V, Pejakovic V, Csanyi T, Hekele O, Huber M, Rodriguez Ripoll M. Surface engineering of Ti6Al4V surfaces for enhanced tribocorrosion performance in artificial seawater. Materials & Design 2016; 104: 10-18.

[2] Totolin V, Göcerler H, Rodriguez Ripoll M, Jech M. Tribo-electrochemical Study of Stainless Steel Surfaces during Chemical-Mechanical Polishing", Lubrication Science 2016, DOI: 10.1002/ls.1336.

[3] Pejakovic V, Totolin V, Göcerler H, Brenner J, Rodriguez Ripoll M. Friction and wear behavior of selected titanium and zirconium based nitride coatings in Na_2SO_4 aqueous solution under low contact pressure, Tribology International 2015; 91: 267-273.

Acknowledgements

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