Characterization of MoS2 in Extreme Environments

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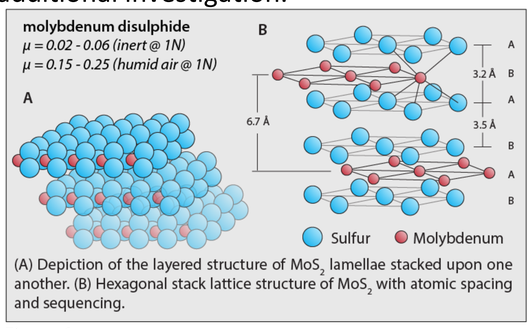
Introduction

- Molybdenum disulfide (MoS2) is a dry film lubricant that is commonly used in aerospace applications.
- MoS2 can produce low friction via its layered structure.
  - Mo and S have strong covalent bonds in its layers
  - Weak Van Der Waals forces between layers allow for low shear (Low friction)
- Although MoS2 is known for low wear and friction in low pressure environments, it's properties in cold environments needs additional investigation.



(A) Depiction of the layered structure of MoS_2 lamellae stacked upon one another. (B) Hexagonal stack lattice structure of MoS_2 with atomic spacing and sequencing.

Figure 1.

Methods

- A pre-existing 6 station linear reciprocating tribometer with a temperature-controlled stage was modified to produce target testing conditions.
  - Normal load of 1N or less
  - Ball on flat geometry
- The samples were produced by sputtering MoS2 on to 440C stainless steel substrates.
- "Stripe tests" were conducted to analyze wear life of samples.
  - As cycles increase, the stroke length decrease
  - Produces sections that represent a certain number of sliding cycles
- Each sample was tested for 50,000 cycles, three times at 20°C, and three times at -60°C.
- Friction data was recorded with an app made with MATLAB.
- A scanning white light interferometer was used to measure the wear of each experiment (SWLI).
  - A 3D scan of the wear tracks is produced allowing for a wear volume to be calculated

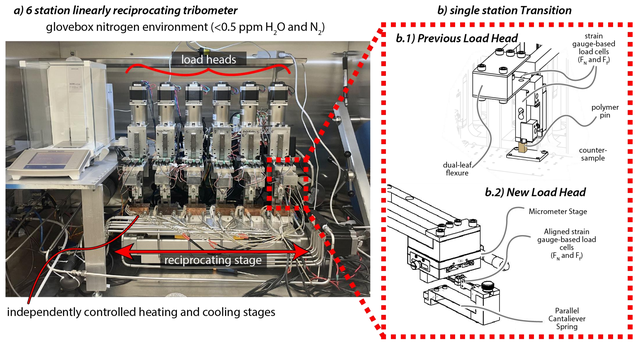


Figure 2. The previous load head featured a pin on disk contact with 250N of force. The new load head uses a ball on flat contact with 1N of force.

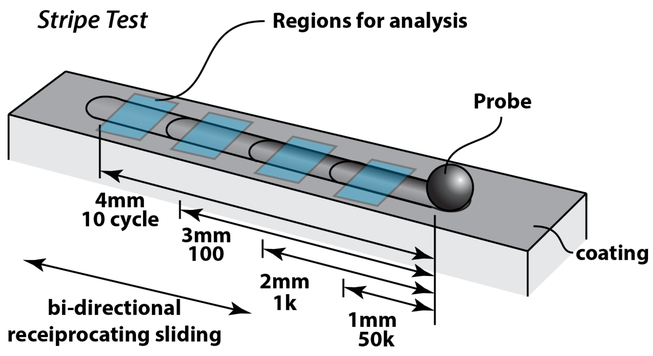


Figure 3. Distinct sections corresponding to the number of cycles are created using a stripe test.

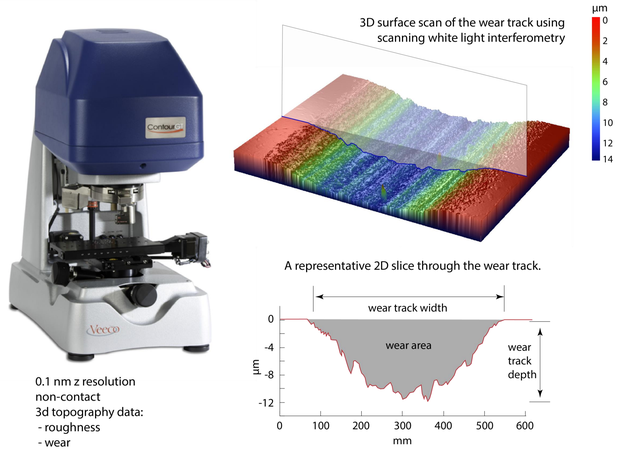


Figure 4. By analyzing the wear scar using a scanning white light interferometer, a wear volume can be calculated.

Results

- At 20°C, MoS2 exhibits low friction and wear properties.
  - Coefficient of friction around 0.05
  - Wear rate of 10^{-7}m/Nmm^3
- Unfortunately, data at -60°C has not been obtained yet, but it is expected that MoS2 would perform worse in colder environments.

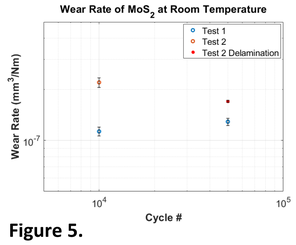


Figure 5.

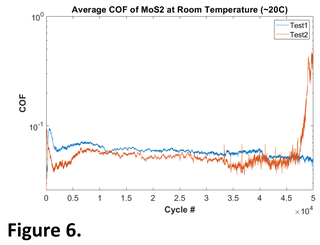


Figure 6.

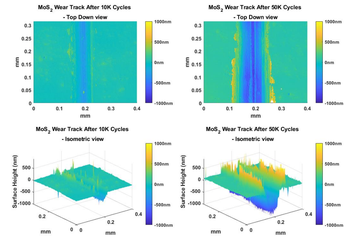


Figure 7.

Discussion

- As expected, MoS2 performs well in a room temperature environment, although delaminating after ~50,000 cycles.
- Although MoS2 is known to exhibit higher friction in colder temperatures, it could still be an effective lubricant for cold temperature applications.
- Further testing at -60°C is needed to understand the behavior of MoS2 in cold environments.

Acknowledgements

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References