

Novel MoS_x and a-C/MoS_x hybrid coatings by vacuum arc deposition for use in dry air and high vacuum

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KEYWORDS

Friction; Coatings; Solid lubrication, Space tribology

ABSTRACT

Dry air and vacuum environments present unique challenges for tribological systems like rolling and sliding bearings due to the absence of liquid lubricants and humidity. While MoS₂ is a commonly used solid lubricant for use in vacuum, it exhibits low wear resistance and is unable to withstand high contact pressures.

Satisfactory MoS₂ coatings can be applied using optimized PVD sputtering processes. Nonetheless, even these coatings are not perfect due to nano-porosities and the long-term durability is limited. Also because solid lubricants such as MoS₂ are soft due to their dichalcogenide structure, there is still a need for high-quality MoS₂ coatings or better wear-resistant alternatives.

In non-lubricated environments with average atmospheric humidity, super-hard hydrogen-free tetrahedral amorphous carbon coatings (ta-C) can be used to address these issues, but they show poor friction performance in vacuum and dry air [1]. To overcome both of these problems, hybrid coatings consisting of both hydrogen-free amorphous carbon and MoS₂ are being considered in order to combine the advantageous properties of both coatings, a concept that was investigated some time ago by Voevodin et al. [2].

Another way to improve the long-term durability of MoS₂ coatings is the concept of microstructuring, which leads to reservoir formation in the micro-dimples on the surface. As it is known that minute quantities of MoS₂ are sufficient for its lubricating effect, such systems are expected to significantly prolong the tribological effectiveness of the MoS₂ lubricant.

This article describes the tribological properties of MoS₂ coatings and modifications using the above-mentioned concepts (hybrid coatings and microstructuring). The special aspect is that the MoS₂ coatings are not deposited using a sputtering process, but using a laser-arc process. This PVD process generates a 100% ionized coating plasma and high particle energies, so that a different MoS₂ film growth occurs than in sputtering processes.

The surfaces were structured using an effective laser structuring method known as direct laser interference patterning

(DLIP). It produce textured surfaces having a periodic surface topography with feature dimple sizes in the micrometer range.

For tribological investigations the coatings were investigated in dry air in oscillation mode (SRV4 Tribometer from Optimol Instruments, Germany) and in vacuum conditions (Pressure: 1 to 5 x 10⁻⁷ mbar) in rotation mode (custom-build high vacuum tribometer, from TETRA Ilmenau, Germany).

First experiments were used to evaluate the effect of C/MoS_x ratio on friction and wear. It was found that the C/MoS_x ratio influenced the coefficient of friction as well as the wear of the coatings strongly in both dry air and vacuum. A trend of lowering friction coefficient with rising MoS_x percentage could be seen. Using Raman spectroscopy, the formation of crystalline MoS₂ was observed in the wear track for some evaluation conditions. In contrast, outside of tribological wear tracks, the MoS_x phase was fully amorphous.

Very promising results were obtained with pure MoS₂-coatings deposited by Laser-Arc deposition compared to state-of-the-art coatings from other suppliers. This is attributed to the dense structure of the coatings due to the high ion energy during deposition avoiding the formation of pores in the films.

The lifetime of the coatings could be improved by combining the DLIP-Laser-structuring prior to deposition followed by MoS₂-coating. In a long-term tribotesting at ultra-high vacuum a low COF ~ 0.02 and low wear were found. The wear depth less of the coating was less than the DLIP-microstructure depth, i.e. the reservoirs filled with MoS₂ were still intact.

REFERENCES

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