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Complimentary XPS and AES Analysis of MoS_3 Solid Lubricant Coatings

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Molybdenum disulfide (MoS_2) nanoparticles are an ideal additive in solid coatings for lubricating mechanisms in vacuum environments, with widespread application in the spacecraft industry. The formation of these nanoparticles however can be complex, and the use of MoS_3 nanoparticles, which are produced using a simple wet chemical synthesis is being explored as an alternative.[1] The use of MoS_3 as a tribological material has not been explored beyond its use as an oil additive.[2] There is new interest in investigating its potential for use in solid lubricant coatings.

To aid in the evaluation of the tribological performance of a MoS3-formulated coating compared to MoS_2 based coatings, x-ray photoelectron spectroscopy (XPS) and Auger electron spectroscopy (AES) are utilized as complimentary techniques for the surface characterization of the contact wear regions created on the coating surface.

The micro-XPS results provided quantitative chemical characterization that complement high spatial resolution AES imaging analysis of the molybdenum sulfide nanoparticles. A unique scanning micro-focused monochromatic x-ray source was used to provide x-ray excited secondary electron images (SXI) of the 50-100 μm wide wear track. The SXI images provide the ability to observe topography and regions with differences in photoelectron yield, making them very useful in locating features with different surface chemistry.

The MoS_3 nanoparticles were produced using simple wet chemical synthesis and are 20 nm to 30 nm in size. The nanoparticles are amorphous, and are contained in a dry coating comprised of a phenolic resin binder, similar to many commercial coatings used on spacecraft and in the aircraft industry.

The tribology of the resin-bonded MoS_3 nanoparticle coating is comparable to similarly prepared bonded coatings containing MoS_2. Tribometer testing showed the MoS_3-formulated coating performed similar to the MoS_2-based coatings, with similar coefficients of friction and endurances in dry nitrogen, with excellent solid lubricating properties.

The results of micro-area AES surface analyses within the contact wear region reveal changes in composition of the coating surface (Figure 1). The AES results are able to confirm the spatial distribution of MoS_3 particles in the binding material of the coating, and conversion into thin MoS_2 films in parts of the wear track.

The micro-area XPS surface analysis results of the wear region show a surface composition that is consistent with the production of a thin film of MoS_2 in the contact wear region (Figure 2). The results also show that after prolonged tribometer testing, the coating within the contact wear region does not fully convert to MoS_2.

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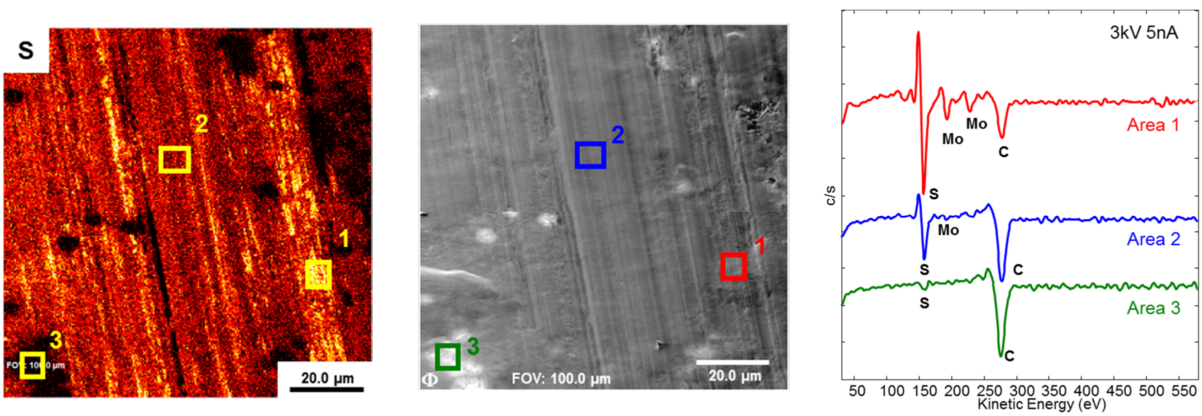

Figure 1. AES small area analysis within the wear track using a 3kV electron beam. The S map and spectral analysis highlight areas where MoS_2 has formed.

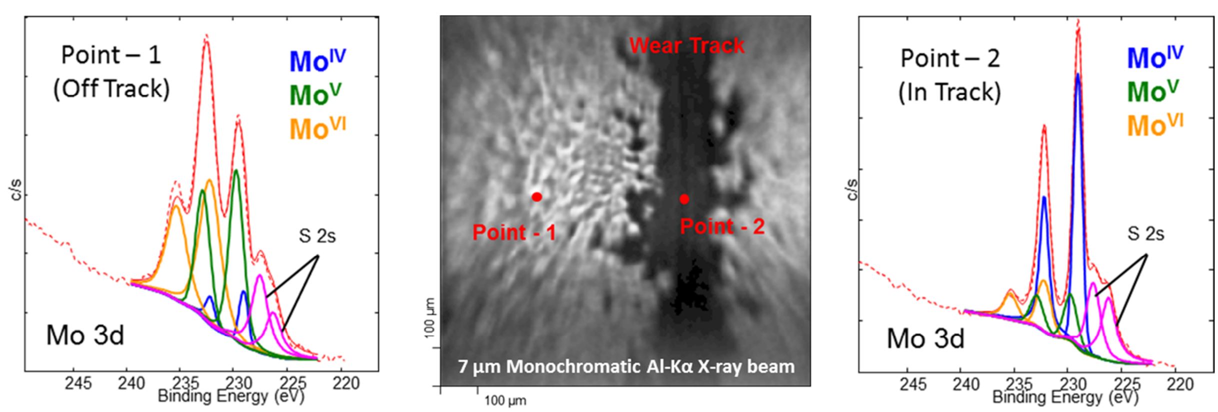

Figure 2. XPS Analysis of the track using a 20 µm scanning x-ray beam, shows an increase of MoS_2 formation in the contact region.

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