Influence of Sliding Velocity and Exposure Time on the Tribologically-Induced Oxidation in High-Purity Copper

CATEGORY OR KEYWORDS

Tribooxidation, copper, sliding velocity, diffusion mechanisms, electron microscopy techniques

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ABSTRACT

Tribo-oxidation is an often observed but far from fully understood phenomenon during friction and wear, taking place by tribochemical reactions of the tribo-partners or the surrounding medium. These reactions in most cases lead to a change in the surface properties such as the mechanical properties and chemical composition and consequently result in a different friction and wear behavior. The aim of our research is to elucidate the elementary mechanisms of tribologically-induced oxidation by paring polycrystalline high-purity copper plates with sapphire spheres. The experiments are performed at room temperature in a strictly controlled atmosphere with reciprocating linear sliding under mild tribological loading.

Our results show the formation of amorphous oxygen-rich cuprous-oxide (Cu_2O) islands which are formed below the surface and grow to hemispherical amorphous/nanocrystalline cuprous-oxide clusters. We relate the growth of the clusters to the diffusion of oxygen on and in copper but the exact pathways of the oxygen are still elusive. After the islands have grown, they coalescence and form a continuous oxide layer on the surface, determining from then on the tribological properties of the contact. This oxidation process takes place at rates order of magnitudes faster than the native oxidation of copper in contact with the same environmental conditions. This works aims to understand the influence of the sliding velocity and the exposure time after the tribological loading to the controlled environment on the formation of these oxide clusters. We systematically vary the sliding speed from 0.1 to 5.0 mm/s and the exposure time from 0, 2.5, 24 to 48 hours and investigate the resulting microstructure. Scanning and transmission electron microscopy techniques are used in order to reveal the fundamental mechanisms of tribologically-induced oxidation. Once understood, this will help for tailoring the materials properties in order to achieve superior tribological performance.

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