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Influence of Environment on Wear of Al-Si Alloys

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Aluminum-Silicon alloys are of considerable and growing interest owing to their use in automobile engines and other wear-intensive applications. Studies have indicated that the environment and the microstructure of alloys each play a significant role in wear behavior [1-3]. In this work, the wear of Al-Si alloys was studied in pin-on-disk tribotests in different environments, including air and dry argon. The counterface in all tests was yttria-stabilized zirconia. Both the worn Al-Si surfaces and the undeformed ones were examined in considerable detail using transmission electron microscopy (TEM). The TEM specimens had been cut from the surfaces with the aid of a focused ion beam (FIB) microscope. Thinned samples were examined in a TEM operating at 200kV to which an energy dispersive x-ray spectrometer (EDS) was interfaced so as to collect elemental X-ray maps.

The as-cast Al-Si consisted of 1-2 μm diameter grains of silicon in an aluminum matrix in which aluminum oxide (as confirmed by EDS) was also present (Figure 1). It was found that wear of the Al-Si specimens was reduced approximately 50% by the removal of oxygen from the test environment. The zirconia counterfaces showed measurable wear after tests done in air, while there was little wear of the zirconia for tests conducted in argon. Wear tracks on the surface of the Al-Si pin showed holes where material has been pulled out of the surface (Figure 2). TEM analysis was performed on specimens taken from beneath the worn surface of the pins (Figure 3). These showed that the near-surface regions beneath the wear track had seen considerable mechanical mixing (Figure 4). The mechanically mixed regions for specimens that had been worn in air contained a considerable amount of both aluminum oxide and zirconium oxide (as confirmed by EDS). The aluminum oxide particles had evidently acted as third body abrasive particles to remove material from the zirconia counterface, and both types of oxide ended up being mixed with aluminum and silicon in the near-surface regions beneath the wear scar (as shown in Figure 2). In contrast, TEM analysis of the Al-Si specimens that had been worn in argon showed no significant presence of either zirconium oxide or aluminum oxide in the mechanically mixed regions.

References

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[2] M. Chen et al., *Wear* 263 (2007) 552.
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Fig. 1. Bright field TEM image of the undeformed as-cast microstructure.

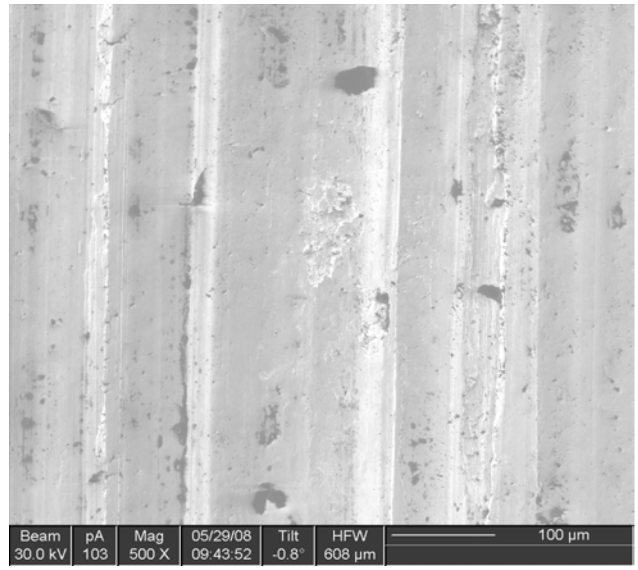

Fig. 2. Secondary electron image of wear track on surface of Al-Si pin. Note the holes where material has been pulled out of the surface.

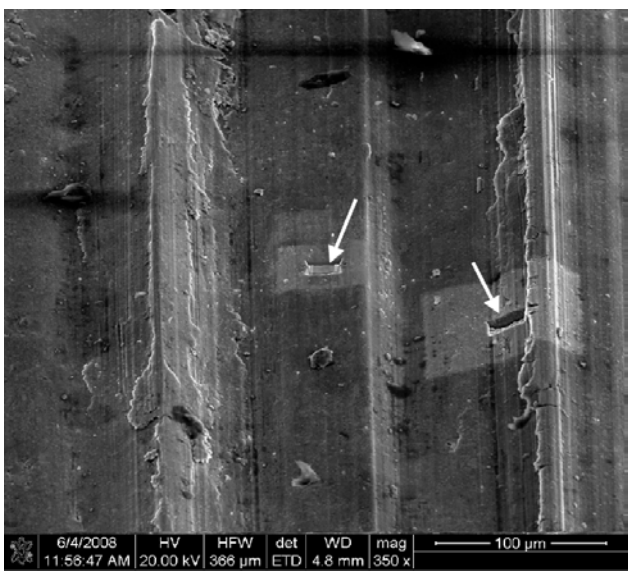

Fig. 3. Secondary electron image showing pits (arrowed) from which TEM specimens were removed using a FIB.

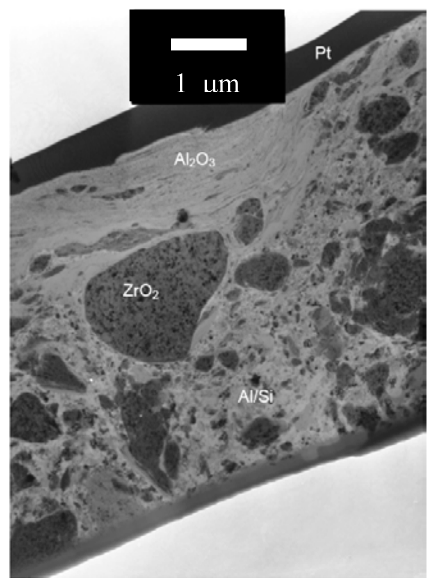

Fig. 4. Bright field TEM image of subsurface region in wear pin. The wear surface is at top. The Pt strip was deposited in the FIB to protect the surface while machining with the FIB. The region labeled Al/Si consists of fine-grained aluminum with fine particles of silicon. The gray regions with dark speckles, such as the one labeled, are zirconia

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