Effect of the countermaterial on the tribological behavior of $Cu_{45}Zr_{46}Al_7Nb_2$ Bulk Metallic Glass

Abstract (300 words):

Bulk Metallic Glasses (BMGs) are currently of great interest for both research and industrial fields. These amorphous metallic alloys result from the extremely fast cooling of a liquid metal into a solid state without crystallizing. BMGs are known for their exceptional mechanical properties. However, their tribological behavior is still highly debated and misunderstood. The present study aims at investigating the influence of the nature of the counterpart on the tribological response of $Cu_{45}Zr_{46}Al_7Nb_2$ BMG. Reciprocating linear ball-on-plate friction tests were conducted with the plate being made of BMG. Six different materials have been selected as counterparts: AISI52100 steel, AISI440C stainless steel, bronze, brass and BMGs ($Cu_{45}Zr_{46}Al_7Nb_2$ and $Zr_{60}Cu_{28}Al_{12}$). Post-test analyses (confocal microscopy, SEM/EDS) and friction coefficient variations highlighted a strong dependence of the tribological behavior on the countermaterial. Countermaterials can indeed be divided in two unexpected categories. First, the tribological behavior of bronze, AISI440C and BMG counterparts against BMG plates is characterized by a wear rate of the BMG plate superior to 5.10^{-5} mm^3/Nm and a friction coefficient close to 0.5. Second, brass and AISI52100 constitute another category, with wear rates about ten times lower. However, the friction coefficient is exceptionally low for brass and high for AISI52100, respectively 0.2 and 0.6. The observed behaviors are due to tribochemical reactions resulting in singular third bodies. On one hand, during friction between bronze, AISI440C and BMG balls against BMG plates, the third body is composed of the oxidized elements of the BMG. On the other hand, the third body is made up of wear debris originating from the ball when sliding against AISI52100 and brass, explaining a high wear resistance of the BMG. This countermaterial dependence enables to predict the tribological response of BMGs depending on the intended application.

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Keywords (max 4):

Bulk Metallic Glasses, countermaterial, third body, tribolayer