EFFECT OF TEMPERATURE ON SELF-HEALING AND WEAR BEHAVIOR OF COPPER OXIDE DOPED ZIRCONIA-ALUMINA SYSTEMS

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ABSTRACT

Structural ceramics are used in diverse tribological applications since they possess unique properties like resistance to wear and corrosion under high temperature conditions. Basically, solid lubricants are used in sliding ceramic contacts in order to decrease friction and increase wear life. In case the interface between two contacting ceramics contains a solid lubricant, the material can resist to contact stresses imposed by sliding motion. One approach to obtain a solid lubricant in the interface is to embed a solid lubricant into a hard ceramic matrix. This results in so called self-lubricating ceramic composite [1]. During contact the solid lubricant is squeezed out and forms a soft interfacial layer. This layer is sheared and plastically deformed and removed from the contact in further sliding and can be restored and in this way material heals itself. Previously [2] a mechanical model has been built to predict the thickness of a self-lubricating layer of ceramic composite materials containing a solid lubricant during dry sliding tests. The work presented here involves an extensive experimental investigation of wear of cupper oxide doped Yttria stabilized Tetragonal Polycrystalline Zirconia (Y-TZP) as a function of temperature. It has been reported that CuO show extensive plastic deformation at temperatures > 600 ·C [3]. This property makes CuO suitable as a solid lubricant under these conditions.

In short, 5(%wt) CuO doped Y-TZP discs have been prepared using pressureless sintering at 1500 ·C for 8 hours. To study friction and wear, CuO doped Y-TZP discs have been tested against an alumina counterface using a pin on disc configuration (load = 1 N and sliding velocity = 0.05 m/s). The effects of temperature on the formation of the self-healing interface layer have been investigated using SEM/EDX and XPS.

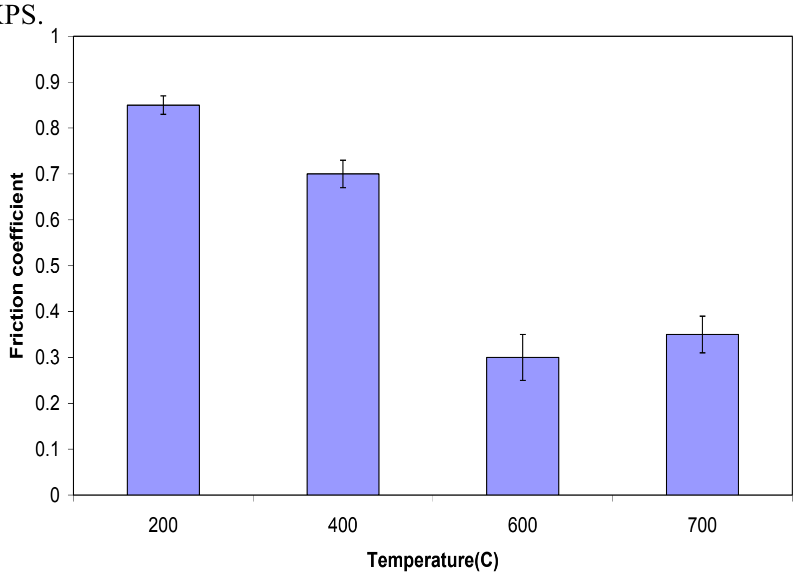

Figure 1- Coefficient of friction as a function of temperature for CuO doped Y-TZP discs sliding against alumina, Load = 1N, Mean Hertzian contact pressure = 350MPa, Sliding Velocity = 0.05 m/s.

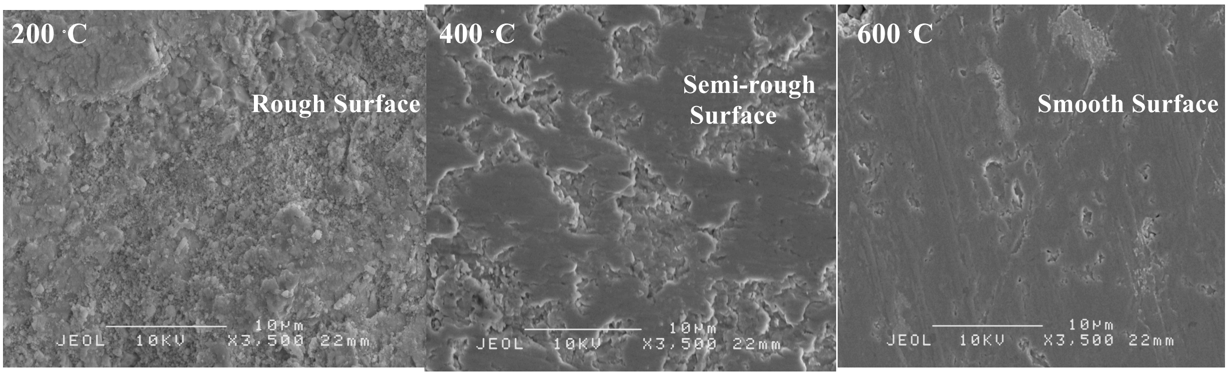

Figure 2- Wear tracks of the CuO-TZP discs sliding against alumina at different temperatures.

Figure 1 shows the coefficient of friction as a function of temperature. It is obvious that friction reduces as the temperature increases. According to the figure, CuO doped Y-TZP shows low friction at high temperatures (T > 600 °C). It is worthy to mention that CuO-TZP exhibits a very low wear rate when the temperature is increased to more than 600 °C. However, the CuO-TZP discs at lower temperatures show high wear rates (T < 600 °C). In order to analyze the tribological behaviour, the wear mechanism both the wear track on the discs and wear scar on the balls has been investigated. Figure 2 shows the SEM micrographs of wear track on CuO-TZP discs at different temperatures. Based on this figure, a smooth surface is formed on the wear track when the temperature is increased to 600 °C. However, the wear track shows a rough surface at 200 °C and 400 °C during sliding tests. SEM micrograph of alumina ball sliding against CuO-TZP disc at 600 °C show very smooth surface (figure 3). Furthermore, EDX analysis of the wear scars of the alumina ball sliding against CuO-TZP at 600 °C shows a transfer layer at the edge of the contact which mainly consists of CuO. XPS depth profile indicates a copper thin layer, with a thickness of < 100 nm, on the CuO-TZP/alumina interface at 600 °C.

Based on these results, we believe that a soft copper oxide inerfacial layer which can plastically deform at >600 °C is responsible for low wear and friction of CuO-TZP. This soft layer can heal itself by transport of grain boundary phase to the surface while the alumina ball slides against CuO-TZP disc.

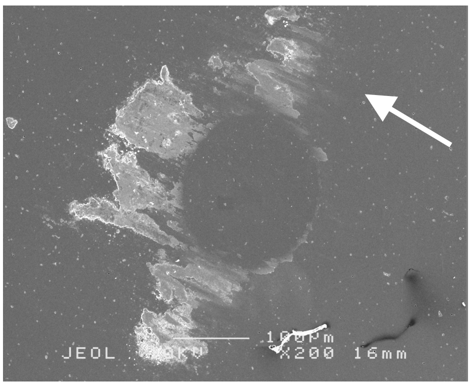

Figure 3 - SEM micrograph of alumina counterface sliding against CuO-TZP at 600 °C (arrow shows sliding direction).

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