Chapter 2
Material and Tribology Issues of Self-Lubricating Copper Matrix Composite

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ABSTRACT

This chapter addresses fundamental issues (i.e. material issue and tribology issue) of the self-lubricating copper matrix composite under dry sliding contact. The development of metal matrix composites for tribological applications relies largely on a trial-and-error method because no adequate knowledge from tribology is involved. To make good metal matrix composites for tribological applications, knowledge from both materials science and tribology are required. This chapter comprehensively introduces the tribological aspect of self-lubricating copper matrix composites for tribological applications. The main mission of this chapter is to introduce the tribological consideration in fabricating copper matrix composite (Cu- graphite and Cu-SiO_2 composites as examples) for tribological application. Material aspect (e.g. mixing method, sintering temperature) is briefly reviewed. The main concern is variations of chemical composition, microstructure, and property of tribo-layer of copper matrix composites sliding against different counter-face materials and under different operating conditions.

1. INTRODUCTION

For many years till now, the development of metal-matrix composites (e.g. copper matrix composites) for tribological applications relies largely on the material aspects, i.e. design (amount and particle size of solid lubricant, etc.) and processing. Once the matrix and solid lubricant of a self-lubricating metal matrix composite is specified, the tribological property of the composite is adjusted by processing parameters (e.g. mixing method, sintering temperature). This is the same

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situation for a metal matrix composite as a braking component. That is why many materials scientists believe that they can make a good metal matrix composite for tribological applications simply based on their knowledge of materials science and technology. This is, however; a trial and error method which is time consuming because no knowledge from tribology is involved. To make good metal matrix composites for tribological applications, knowledges from both materials science and tribology are required. This chapter devotes to comprehensively introducing the tribological aspect of copper matrix composites for tribological applications. In recent years, the investigations on tribological behavior and tribo-layer of copper matrix composites (Cu- graphite and Cu- SiO_2 composites) have been conducted by the authors' group at Lanzhou Institute of Chemical Physics and Northwest University at Xi'an. The focus is not on material aspect but on tribological aspect. We realize that the tribo-interface is strongly modified by friction and wear. It is the tribo-interface that controls the friction and wear of the tribo-pair. The key to understand the tribo-interface is characterization of the tribo-layer on the worn surface of metal-matrix composite. The formation and evolution of the tribo-layer reveal that the microstructure and property of the tribo-layer are time-dependent. The evolution of the tribo-layer can be revealed by the shape and chemical composition of the wear debris. The tribo-layer can be modified by counter-face material and its surface finishing, as well as operating conditions (e.g. sliding speed, normal load).

The mission of this chapter is to introduce the tribological consideration in fabricating self-lubricating copper matrix composite (Cu- graphite composite as an example) for tribological application. Material aspect will be briefly reviewed. The main concern is variations of chemical composition, microstructure and property of tribo-layer of copper matrix composites sliding against different counter-face materials and under different operating conditions.

2. SELF-LUBRICATING COPPER MATRIX COMPOSITE

2.1 Self-Lubricating Copper Matrix Composite and Its Application

Self-lubricating copper matrix composite is a two-phase or multiphase material with copper or copper alloy as the matrix and most commonly graphite or MoS_2 as solid lubricant (Tsuya, Shimara, & Umeda, 1972; Kestursatya, Kim, & Rohatgi, 2003). The word *multiphase* is used here because ceramic particle as a third phase (e.g. SiC, Al_2O_3) is sometimes used as a strengthening component but is neither the matrix nor a solid lubricant. Self-lubricating copper matrix composite can be in form of either a free-standing part or a coating. In this chapter, a self-lubricating copper matrix composite refers to a free-standing part unless otherwise stated.

The matrix is the binder for solid lubricant and makes the composite strong enough (adequate mechanical strength) to serve as mechanical component. Copper has a melting point of 1083 °C and high ductility and good electrical conductivity. Compared with pure copper, copper alloys (e.g. Cu-Sn, Cu-Pb, Cu-Zn, Cu-Sn-Pb-Zn) have higher hardness and mechanical strength but lower electrical conductivity and corrosion resistance. In general, the volume fraction of the matrix is higher than that of the solid lubricant. In some cases, however; solid lubricant compact with high volume fraction (50% or even higher) can also be classified as self-lubricating copper matrix composite but is not included in this chapter.