WCu Composite Manufacturing Technologies

Introduction

Powder metallurgy (PM) is the main method used in WCu fabrication. This note discusses briefly the three more specific methods used: high-temperature liquid-phase sintering, reactive sintering and infiltration.

High-temperature Liquid-phase Sintering

Tungsten has a much higher melting point than copper. This enables the use of high-temperature liquid-phase sintering to prepare WCu composite materials. Being a simple and mature process, it includes steps shown in Fig 1. However, it has some disadvantages which are its high sintering temperature, long sintering cycle, and relatively low sintered body density (typically at 90 to 95% theoretical density). In order to obtain qualified materials for heat sinks, it is necessary to further process high-temperature liquid-phase sintered WCu materials using forging, hot pressing, and other methods. The additional steps limit the use of high-temperature liquid-phase sintering method.

Fig 1. Basic steps of high-temperature liquid-phase sintering

Reactive Sintering

The typical sintering aids Pd, Ni, Co, Fe, and others are used in this method. They help to reduce the sintering temperature and time, and at the same time increase the sintered density. Co and Fe are the best sintering aids for WCu composites. Taking W90Cu (90% W) as an example, when Co content is 0.35% and the sintering is done at 1,300°C for 1h, the sintered composite has a 99% theoretical density, hardness of 300 HV, and flexural strength of 300 MPa. As Ni and Pd are infinitely soluble in molten copper, both Ni and Pd can form alloys with Cu, thus making them not as ideal as Co and Fe which are only partially soluble. Co and Fe can form an intermetallic compound to improve tungsten densification in the sintering process. However, the addition of sintering aids significantly reduces the electrical conductivity and thermal conductivity, which limits the use of reactive sintering in making WCu heat sinks. Fig 2 illustrates a typical process of reactive sintering.

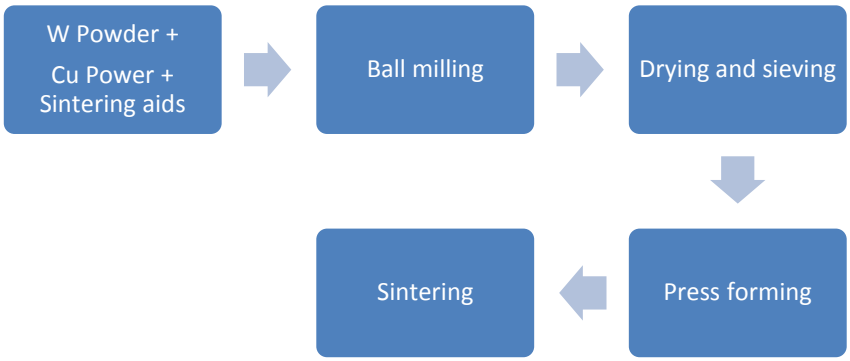

Fig 2. A typical process of reactive sintering

Infiltration

The infiltration method is now the most common way to manufacture WCu heat sinks. Fig 3 shows some WCu heatsinks.

Fig 3. Some typical WCu heatsink parts

In this method, a dry-pressed tungsten skeleton is prepared first, and then molten copper is infiltrated into the skeleton. Wetting and the capillary force play an important role in filling the micro-cavities inside the green body. Fig 4 illustrates a typical process of this method.

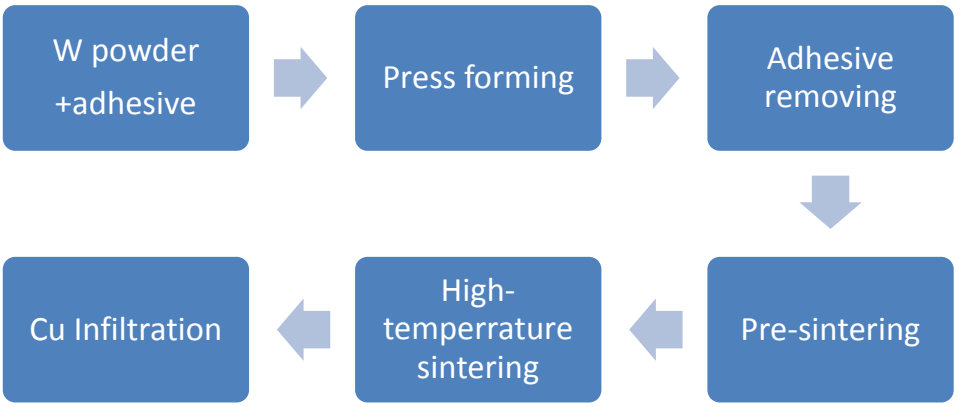

Fig 4. A typical infiltration process of preparing WCu

Products from infiltration have high density, excellent electrical conductivity and thermal conductivity. But several machining steps after infiltration can result in higher cost and lower yield. Fig 5 shows a typical process flow of WCu heatsinks, several after-infiltration steps are included.

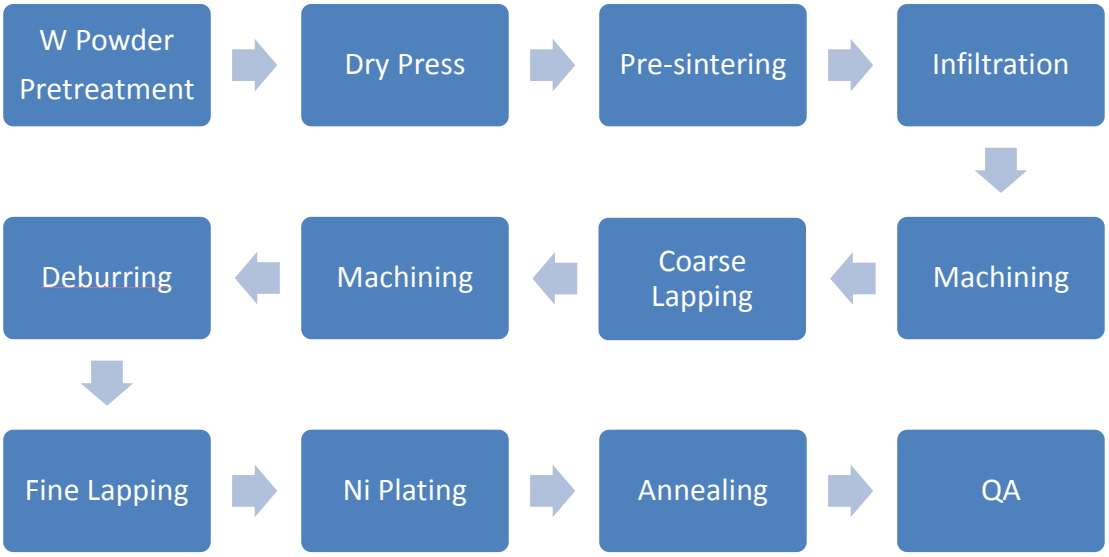

Fig 5. A typical process flow of WCu heatsinks