The Influence of Production Process Parameters on Properties W-Ag, Mo-Ag Composites

Jan Leżański[1, a], Marcin Madej[2, b]

[1, 2] Faculty of Metals Engineering and Industrial Computer Science
AGH University of Science and Technology, Al Mickiewicza 30, 30-059 Krakow
[a] lezansk@uci.agh.edu.pl, [b] mmeydey@poczta.onet.pl

Abstract

Attempts have been made to describe the influence of production process parameters on the microstructure and properties of W - Ag and Mo - Ag composites. The compositions of powder mixtures are W + 30% Ag and Mo + 30%Ag. Silver additions assists densification during sintering by a liquid phase sintering process. The main goal of this work is to compare properties and microstructure of as-sintered and as-infiltrated composites.

Keywords : tungsten, molybdenum, silver, sintering, infiltration, composites

1. Introduction

The W-Ag and Mo-Ag electrical contact materials are produced exclusively by means of powder metallurgy (PM) [1]. Tungsten and molybdenum are used for contacts utilised in heavy-duty applications. Composites containing 30-80wt-% silver resist arc erosion and possess good anti-welding characteristics and acceptable interface resistance. The properties of PM electrical contacts depend on both their composition and manufacturing process. This means that the particle size, and distribution of the refractory phase, the homogeneity of the microstructure, and amount of porosity affect the electrical, mechanical, and thermo-physical properties of the composite material [1,2].
In principle, the W-Ag and Mo-Ag composite materials can be produced by two techniques [1,3]:

- elemental metal powders are mixed, cold pressed and sintered at temperatures below the melting point of silver. For silver contents exceeding 30 wt-% the as-sintered parts can be subjected to final processing by rolling or re-pressing,
- tungsten or molybdenum powders are pressed, or pressed and sintered to produce porous skeleton which is then infiltrated with liquid silver.

Molybdenum is used when electrical loads do not justify the use of tungsten. Molybdenum has lower density than tungsten which is advantageous in situations where the mass of moving parts of the contact must be minimised. Molybdenum-base contacts are used for breaking lower currents and in high voltage electronics. Tungsten is the preferred material in car electronics, as contact-breaker points, for horns, etc. [1,4].

2. Experimental and Results

Selected physical properties of the starting powders are given in Table 1.

Table 1. Physical properties of experimental powders.

Powder	Particle size, [μm]	Tap density, [g/cm^3]	Flow, [s/50g]	Compressibility (600 MPa), [g/cm^3]	Theoretical density [g/cm^3]
W	0 ÷ 10	2,82	-	12,54	19,39
Mo	0 - 10	1,64	-	7,21	10,20
Ag	0 - 63	1,53	60	9,76	10,50

Production of W–Ag and Mo–Ag composites by the sintering route. The W+30wt-%Ag and Mo-30wt-%Ag mixtures were prepared by tumbling the powders for 30 minutes in the Turbula-type mixer. The mixtures were then subjected to a double-press/double-sinter process. The cold pressing operations were performed in a rigid die on a single action press at 600 MPa. Both sintering cycles included one hour hold at 1100°C in hydrogen.

Production of W–Ag and Mo–Ag composites by the infiltration. W+5wt-%Ag and Mo-5wt-%Ag mixtures were prepared by tumbling the powders for 30 minutes. They were subsequently cold pressed in a rigid die on a single action press. The pressure was adjusted individually to assure around 25% green porosity. Prior to infiltration the compacts were sintered in hydrogen at 1200°C for one hour. The porous skeletons were finally contact infiltrated with Ag-1wt-%Ni alloy at 1200°C for one hour in hydrogen

3. Results and Discussion

The properties of the as-sintered and contact infiltrated composites are given in Table 2.

Table 2. The properties of as-sintered and as-infiltrated composites.

Alloy	As-sintered composites		
	Relative density, [%]	Hardness [HB]	Bending Strength [Mpa]
W+30%Ag	**87,5**	**130**	**260**
Mo+30%Ag	**89,9**	**121**	**360**
	As-infiltrated composites		
W+30%Ag	**97,2**	**251**	**650**
Mo+30%Ag	**97,3**	**251**	**251**

From Tab. 2 it is evident that the shrinkage of compacts containing 30wt-% Ag after sintering at 1100°C is negligible; whereas repressing at 600 MPa results in a marked increase in density of the material. As with the first sintering cycle, the re-sintering operation has a negligible effect on the final density of the composites.

Contrary to the double-press/double-sinter process, infiltration enables near-full densification of the investigated materials. As can be seen from Tab. 2, the infiltrated density is in excess of 97% theoretical which results in a marked increase in hardness and almost two-fold increase in bending strength as compared with the double-pressed and double-sintered counterparts.

Typical microstructures of as-sintered and as-infiltrated composites are shown in Fig. 2 and 3.

As illustrated in Fig. 3, the as-sintered microstructures are characterised by even distribution of tungsten/ molybdenum, silver and porosity. The infiltrated microstructures are also characterised by uniform distribution of tungsten/ molybdenum and silver, and small residual porosity.

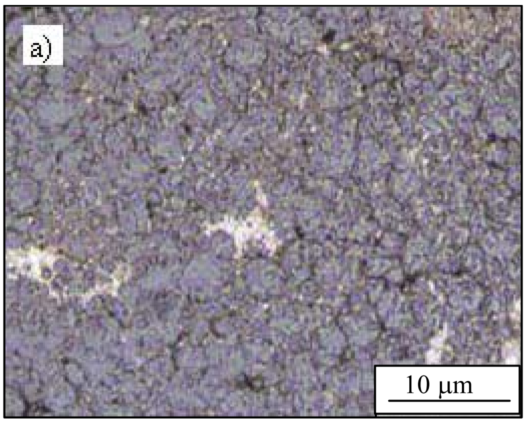

Fig. 2. Microstructures of as-sintered composites W+ 30% Ag.

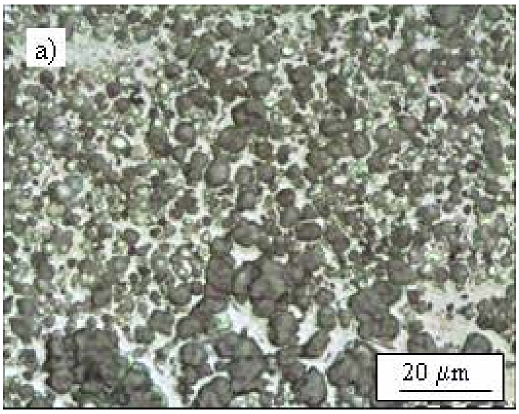

Fig. 3. Microstructures of as-infiltrated composites W+ 30% Ag.

4. Summary

The W+30%Ag and Mo+30%Ag composites obtained from the double-press/double-sinter route display around 10% residual porosity.

The W+30%Ag and Mo+30%Ag composites obtained from the contact infiltration route display near-full density (less than 3% residual porosity).

The infiltrated composites display markedly higher hardness and near two-fold rise in bending strength compared to the as-sintered counterparts.

5. References

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