EFFECTS OF MICROSTRUCTURE ON INTERNAL OXIDATION BEHAVIOR OF SILVER-CADMIUM ALLOY

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Keywords: *AgCdO contact material, Internal oxidation, Grain size*

1. Introduction

Ag/CdO materials have been widely used as contact materials such as single pole switch, double pole switch, multi pole switch, plastic air switch, leak electrical switch, automobile protect switch, microswitch, etc., because it has good electrical conductivity, good thermal conductivity, good anti-arc, and the resistance is low and stable [1~3]. In general, Ag/CdO contact materials can be made through internal oxidation from AgCd alloys. Ag/CdO materials can be divided by one single oxidized Ag/CdO materials and two side oxidized Ag/CdO materials. Single side oxidized Ag/CdO materials can be prodeuced by internally oxidizing a wrought AgCd alloy from one side only, leaving a solderable unoxidized AgCd layer. Two side oxidized Ag/CdO materials can be produced by internally oxidizing a wrought AgCd alloy from both sides leaving a centrally located thin depletion layer of unoxidized Ag rich materials. Secondary operation bonds fine silver to one side producing a backing layer for contact attachment. Both single side oxidized and two side oxidized Ag/CdO materials have unoxidized AgCd layer or Ag rich layer for contact attachment. However, Ag cladding for contact attachment increases manufacturing cost. And single side oxidized Ag/CdO materials can be produced by specific method of manufacturing companies but most of these methods have been hiding. In this work, we tried to investigate an effect of microstructure on internal oxidation behavior of AgCd alloy.

2. Experimental procedure

Hot rolled Ag-10mass%Cd sheet was supplied from Korea Chemical ltd. Table 1 shows the electrical conductivity, hardness and density of as-received. This sheet was heat treated at temperatures of 523 K and 773 K for 1 hr~9 hr in air atmosphere to control grain size. And then internal oxidation was carried out at temperature of 973 K for 1 hr, 6 hr and 24 hr with O_2 pressure of 3atm.

Table 1. Properties of as-received

Material	Property	Value
Ag-Cd (Hot rolled)	Cd concentration (mass%)	10
	Electrical conductivity (% IACS)	51
	Hardness (Hv)	150
	Density (g/cm^3)	9.9

Microstructural observation was performed using optical microscope (OM) and scanning electron microscopy (SEM). XRD was used in determining each of constituent phases. 10ml NH_4OH, 20ml 3% $H_2O_2$10ml distillation water solution was used for etching. Hardness test was carried out using Vickers hardness tester with a load of 300g.

3. Results and discussion

Fig. 1 shows optical micrographs of the as-received and heat treated specimens. Very fine equaxied structures containing a small amount of annealing twin are seen in as-received. It indicates that dynamic recrystallization is completed during hot rolling. Even after heat treatment at 523 K for 9 hr, no discernable change in grain size is seen. However, the grain size is drastically increased after heat treatment at 773 K. Fig. 2 shows the change of grain size after heat treatment at 523 K and 773 K for the present alloy. Fig. 3 shows scanning electron microscopy (SEM) images of AgCd alloy after internal oxidation at 973 K for 1 hr, 6 hr and 24 hr. Oxidation layer is seen in surface area and it is obvious that oxidation layer thickness increases with increasing holding time. And it is found that oxidation progresses through grain boundaries. Therefore, it is expected that the internal oxidation rates has a relation to the initial grain size.

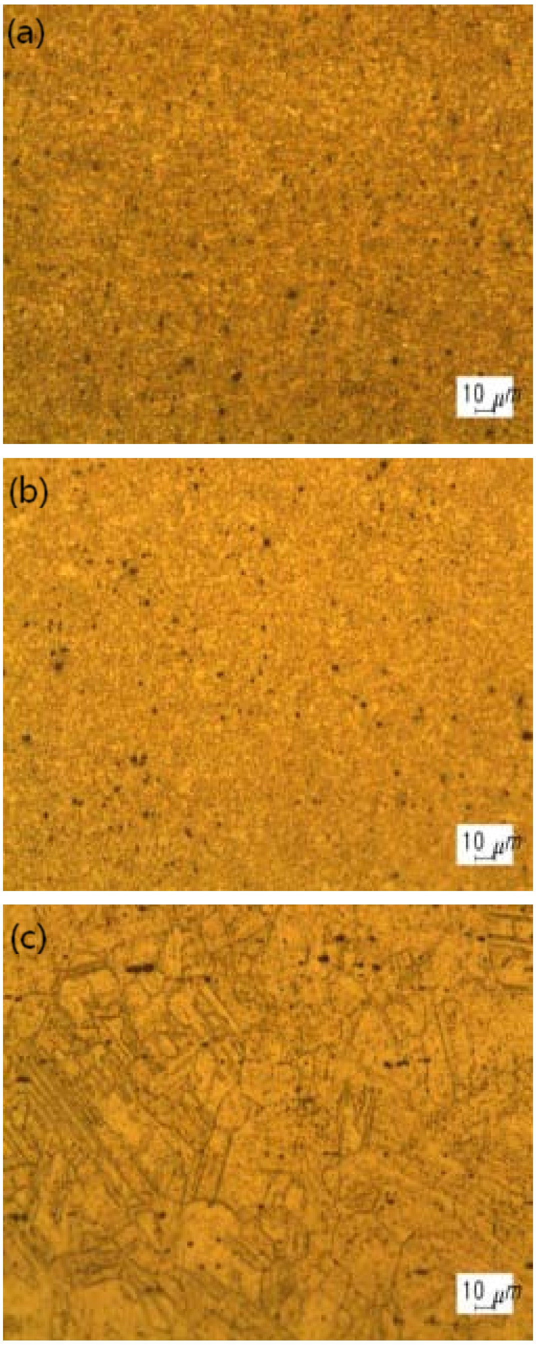

Fig. 1. OM images of the as-received (a), annealed at 523 K (b) and annealed at 773 K (c)

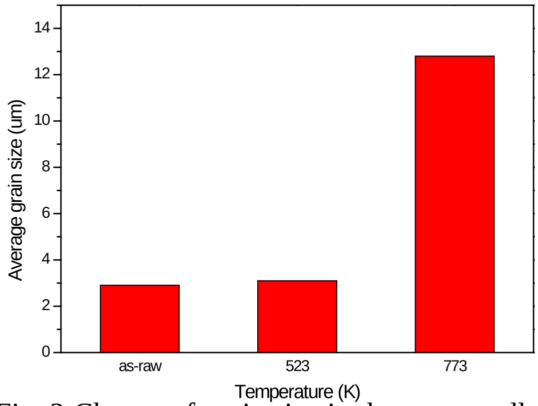

Fig. 2 Change of grain size in the present alloy after heat treatment at 523 K and 773 K for 5 hr

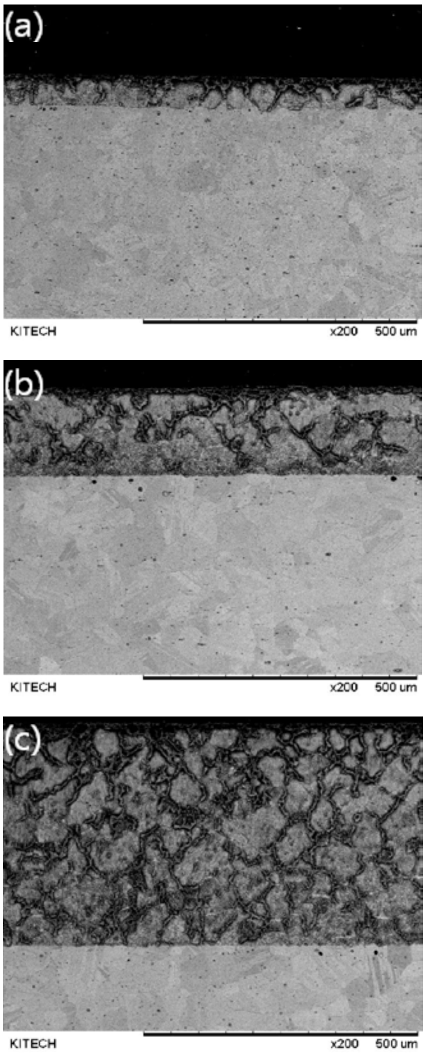

Fig. 3 SEM images of as-received after internal oxidation at 973 K for 1 hr (a), 6 hr (b) and 24 hr (c)

Fig. 4 shows oxidized layer thickness as a function of holding time for the as-received after internal oxidation at 973 K for 1 hr, 6 hr, 12 hr and 24 hr. The oxidized layer thickness drastically increases with increasing holding time at 973 K.

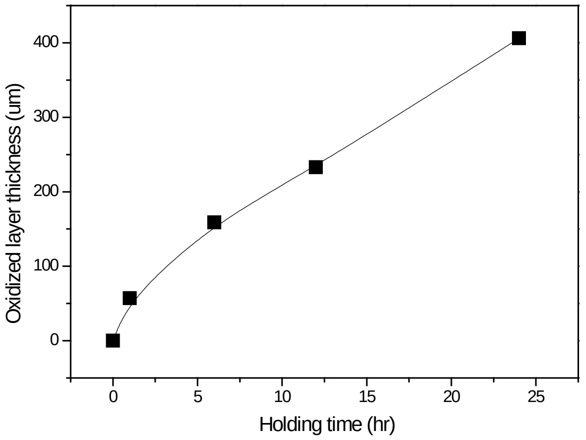

Fig. 4 Oxidized layer thickness as a function of holding time at 973 K for as-received

Fig. 5 shows oxidized layer thickness as a function of holding time for the annealed after internal oxidation at 973 K for 1 hr, 6 hr, 12 hr and 24 hr. Entirely, similar tendency with the as-received is seen. This result may be due that annealing temperature was carried out below the oxidation temperature. Therefore, in order to investigate an effect of grain size on internal oxidation behavior of AgCd alloy, the higher annealing temperature than the oxidation temperature would be needed.

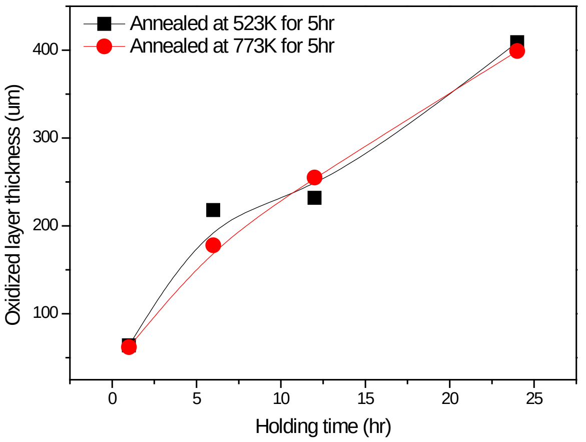

Fig. 5 Oxidized layer thickness as a function of holding time at 973 K for annealed specimens

Fig. 6 shows hardness of oxidized and unoxidized areas for the as-received and the annealed specimens after internal oxidation at 973 K for 24 h, respectively. The hardness of oxidized area was estimated to the range 120~130 Hv and the hardness of unoxidized area was estimated to 55~70 Hv. No discernable difference in hardness between the as-received and the annealed specimens is seen.

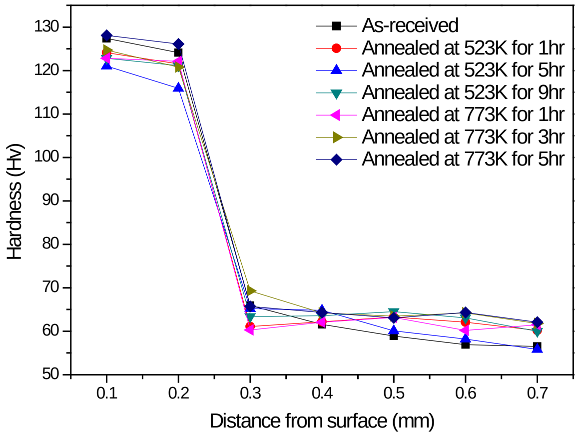

Fig. 6 Hardness of oxidized and unoxidized areas for both the as-received and the annealed specimens after internal oxidation at 973 K for 24 h

4. Summary

In this work, we tried to investigate an effect of microstructure on internal oxidation behavior of hot rolled Ag-10mass%Cd alloy. The as-received was annealed at 523 K and 773 K for 1~9 hr to control grain size. The grain size increased with increasing annealing temperature. After internal oxidation at 973 K for 1~24 hr, it was found that the oxidation occurred from surface and through grain boundaries. The oxidized layer thickness increased with increasing holding time. However, there was no effect of grain size on internal oxidation behavior in the AgCd alloy annealed below internal oxidation temperature because the grain size was depended upon the internal oxidation temperature higher than the annealing temperature.

Acknowledgement

This research was supported by a grant from the Material Strategic Technology Development

Program by the Ministry of Knowledge & Economy (MKE), Republic of Korea.

5. References

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