

### Corrosion Behavior of Copper-silver-phosphorus brazing Alloy in Chloride Containing Electrolyte at Various Temperature

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The families of phosphorus-containing brazing alloys are the most favored alloys when joining copper and copper-base alloys. The copper-silver-phosphorus brazing alloys have much attention as consequences of some good properties when used for joining. However, the failures arise frequent at the braze joint, generally caused and initiated by the corrosion of the brazing alloys. Nevertheless, copper alloy with silver additive has been getting a large attention due to its good properties. Yet, less comprehensive information available for the corrosion behaviour of the brazing alloys.

The present study was intended to observed the behaviour of the copper-silver-phosphorus brazing alloy exposed in the 3.5 wt% NaCl solution. In addition since most studies of the phosphorus containing brazing alloys have been studied at room temperature, this work was performed to study the temperature effect of copper-silver-phosphorus brazing alloy corrosion with temperature at 25°C, 40°C, 55°C and 70°C. This work could be helpful to understand in the field practically because the application temperature is usually higher than that of room temperature in general.

The most stable passivation was observed at 25°C in chloride containing electrolyte as shown in Figure. 1 while the intergranular cracking of the layer produced in lithium bromide solution was observed by A. Valero-Gomez et. al.[1]. On the other hand, narrower active-passive region was resulted as shown on potentiodynamic polarization curves in Figure 1. The dependencies of this active-passive transition to the temperature, explained by gradually decreased with increasing temperature up to 55°C.

Dissolution behaviour dependence to the temperature explained by the tafel slope method and showed the tendency of the corrosion potential and the anodic slope followed the changes of the temperature, shifted to more negative potential, and at higher temperature the slope was steeper than that of lower temperature .

Linear dependence of  $E_a$  and  $I_a$  on the  $v^{1/2}$  obtained by cyclic voltammetry in this present work suggested a passivation was occurred by a diffusion controlled mechanism where the rate of electron transfer is controlled by the rate of supply of material to the electrode by the diffusion process. The passive film becomes less stable at the higher temperature, and it was proved by the FEM-SEM examination in Figure 2. that showed some discontinuities of the corroded area on the surface. Accordingly, much current oscillation at the higher temperature were detected when the potentiostatic polarization was made at each temperature. The discontinuities could lead orthophosphoric acid ( $H_3PO_4$ ) to be produced when the  $Cu_3P$  phase interact with water as described by Idrissi H. et. al and others authors [3,4].

Chloride commonly known as a strong oxidant that could be catalyzed the localize corrosion in some metals. In this work chloride has a strong role in terms of passivation of the copper-silver-phosphorus brazing alloy, similar effect that studied to the pure copper by several authors. The XRD pattern described how chloride

passivated the alloy by producing  $CuCl$  on the surface rather than  $Cu_2O$  as found by Idrissi H. et. al.

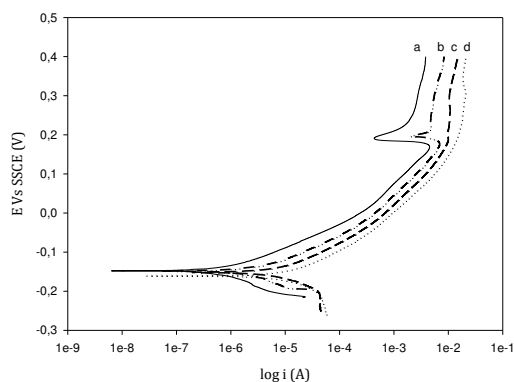


Fig.1. Potentiodynamic polarization curve of copper-silver-phosphorus brazing alloys in 3.5 wt% NaCl solution at various temperature: a) 25°C; b) 40°C; c) 55°C; d) 70°C

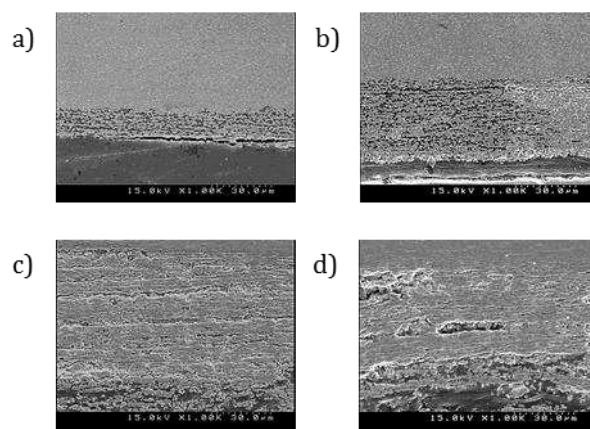


Fig.2. SEM images of the alloys' cross section with 1000x mag. after potentiostatic polarization at 250 mV(SSCE) in 3.5 wt% NaCl solution at various temperature: a) 25°C; b) 40°C; c) 55°C; d) 70°C

- [1] A. Valero-Gomez, A. Igual-Munoz, J. Garcia-Anton, "Corrosion and Galvanic Behavior of Copper and Copper-Brazed Joints in Heavy Brine LiBr Solutions," *Corrosion* (2006), in press.
- [2] Idrissi, H., Millet, J. P., and Audisio, S., "Natural formation of a protective layer on copper and copper brazing in domestic water: structural characterization and electrochemical behavior." *Journal of Materials Science* 29: 5327–5332, 1994.
- [3] D. R. Sigler, J. G. Schroth, Y. Wang, D. Radovic, "Sulfide-Induced Corrosion of Copper-Silver-Phosphorus Brazed Joints in Welding Transformers," *Welding journal*, vol.86, 2007
- [4] Joseph A. Worden, Jorge M. Mundulas, "Understanding, Diagnosing, and Repairing Leaks in Water-Cooled Generator Stator Windings," GE Power Systems, Schenectady, New York, 2008.
- [5] G. Kear, B.D. Barker, F.C. Walsh, "Electrochemical Corrosion of Unalloyed Copper in Chloride Media – a Critical review," *Corrosion Science*, 46, 109-135. 2004.
- [6] H.P. Lee, Ken Nobe, "Kinetics and Mechanisms of Cu Electrodeposition in Chloride Media," *Journal of The Electrochemical Society*, Vol. 133, pp 2035-2043, 1986.