Effect of Alumina on Electrical And Mechanical Properties of Pure Copper

Shakir J. Edrees **Sura Abd Al-Zahra Muhsion**
Non. Metallic Department, Materials Eng. University of Babylon

Abstract

Reinforced copper matrix composite have important in structural members the contacts of switch or relay to maximize the life of the device. Particulate metal matrix composite was fabricated from Cu and 0.1, 0.2 and 0.3% Al_20_3. The effect of alumina content on hardness, tensile strength and electrical conductivity has been investigated. Fine dispersed particles introduced into the metal matrix have significant reinforcing effect. due to their hardness, stability and insolubility in the base metal also represent obstacles to moving of dislocation.

الخلاصة

إن تقوية المواد المركبة ذات أساس من النحاس لها أهمية كبيرة في العديد من التطبيقات مثل مناطق الاتصال في المفاتيح الكهربائية حيث يزيد من عمر الجهاز، وتصنع هذه المواد بإضافة مسحوق الالومينا بنسب وزنية مختلفة (0.1%,0.2%,0.3%) إلى منصهر النحاس.

وقد تم دراسة تأثير إضافة الالومينا على الصلادة ومقاومة الشد والموصلية الكهربائية ، كما إن إضافة الالومينا يؤدي إلى تنعيم البنية المجهرية والذي يعتبر السبب الرئيسي في زيادة الصلادة.

إن دقائق الالومينا الصغيرة المشتتة لها أهمية في تقوية هذه المادة المركبة وان صلادة هذه المادة المركبة ناتجة من استقرارية وعدم ذوبان هذه الدقائق في المادة المركبة والتي تشكل حاجز يمنع حركة الانخلاعات.

1-Introduction

Metal matrix composites (MMCS) consist of a continuous metal or intermetallic matrix phase and either continuous or discontinuous reinforcements. Discontinuous reinforced phase
are most often SiC, Al_20_3, B_4C or Ti B although many other ceramic materials have been used. The reinforcement morphology may be plate-like, whisker or particulate, but particulates (aspect ratio 1~2) are most often used as a result of their widespread availability and lower cost. Primary processing techniques for discontinuous MMCS include powder metallurgy (P/M), stir casting and infiltration casting [Miracle, 2001].

Oxide dispersion-strengthened copper has been identified as an effective method to increase copper strength without seriously decreasing in its electrical and thermal conductivity. Materials used for electrical contacts in switches and relays must have good combination of wear resistance and electrical conductivity. Otherwise the contacts erode, causing poor contact and arcing. [Hussain, 2005].

Reinforced copper matrix has been extensively studied in resent years due to attained better properties than pure copper and copper alloys reinforced by precipitation and solid solution hardening. Obtaining copper-based composites with a fine dispersion of alumina particles seems to be a very common technique in powder metallurgy for this type of a material. [Rajkovic ,2009].

Because of having good electrical and heat conductivity Cu base materials can be widely used as a varity of electrical conductors and actively cooled heat conductors. But its mechanical properties, especially, at high temperatures, can not often meet the requirement [WU, LI, Zhang, Jiang ,1999 , Groza, 1992].

Besides high electrical and thermal conductivity oxide dispersion strengthened copper also retains its resistance to softening at elevated temperature such performance switches [Hussain ,1999].

In order to keep the good conductivity the volume fraction and the size of reinforcement should be small [WU,1999].

In this work, alumina has been used as the dispersord due to its good properties such as high toughness and hardness low bulk density; also it is cheaper than other ceramics, and thermally stable without interaction with the matrix at high temperature.

2-Experimental Work

Copper composites were manufactured by stir casting conventional melting and gravity die casting to producing dispersion strengthened composites. Specimens (1.2 cm in diameter and 6 cm in hight) were obtained from Cu and alumina. The composition of the composites was based on the weight percentage of alumina which are 0.1, 0.2 and 0.3% wt.

Uniaxial tensile test were performed on tensile testing machine with a cross head speed of 3 mm/min for all sample. Specimen with gauge length of 25.4 mm and 5 mm in diameter were used.

For hardness measurement samples from composites were cut and they were wet ground on 320, 400, 800 grit SiC abrasive paper using water as libricant followed by polishing on dimond 15 µm, followed by cleaning in Alchole, sample in the same diamension were used to measured electrical resistivity.

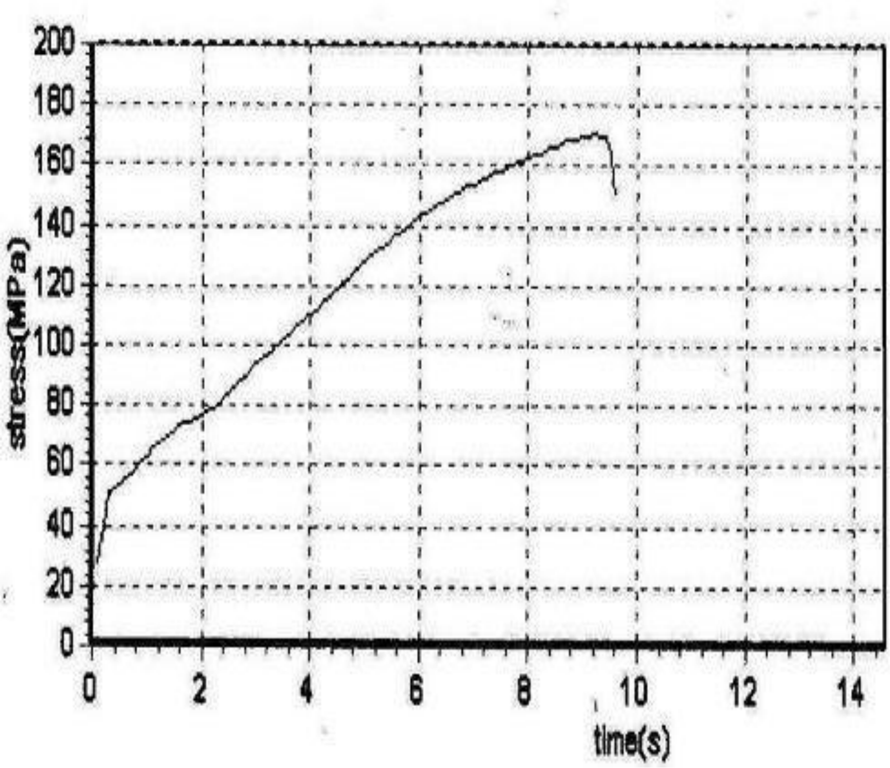
Table (1) chemical composition for samples

Percentage of Al_2O_3	Percentage of Cu	Samples
—	100	A
0.1	99.9	B
0.2	99.8	C
0.3	99.7	D

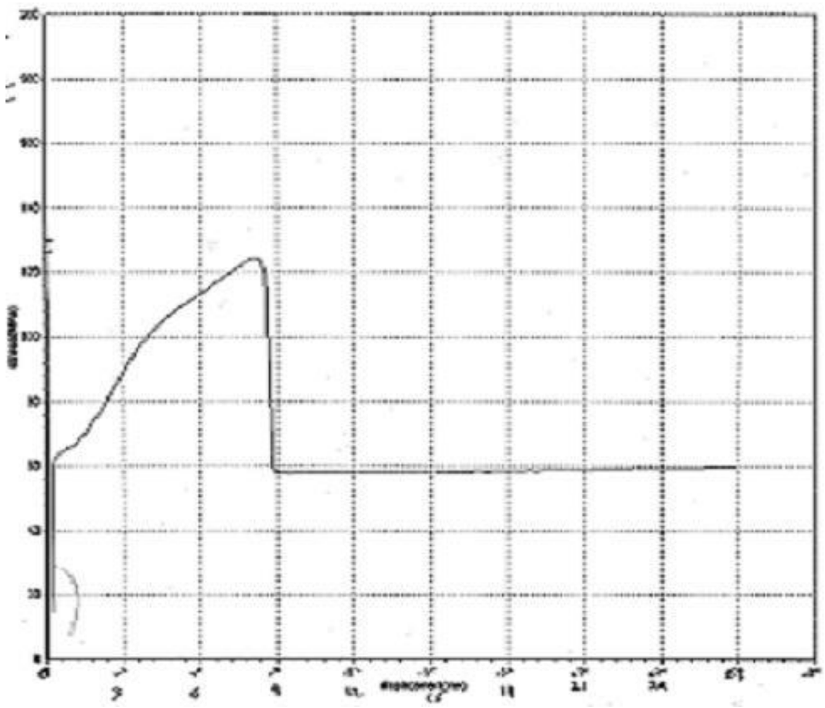
3-Result and discussion

1-Tensile strength and hardness.

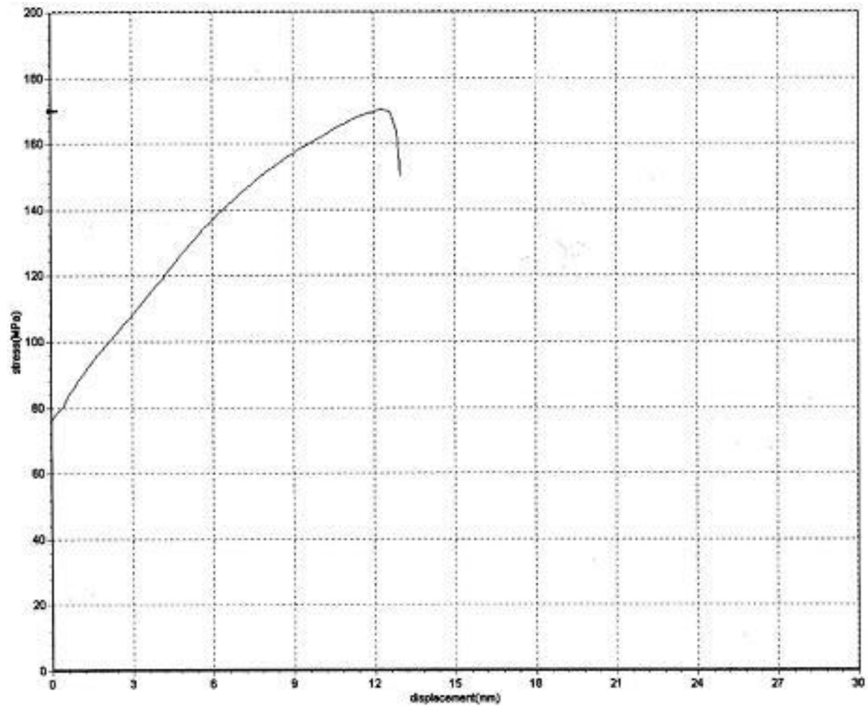
In corporation of ceramic reinforcement in Cu leads to significant improvement in the tensile strength and hardness. Using small volume fraction of reinforcement can lead to the balance between the relatively high conductivity and mechanical properties because the small particles block the movement of dislocation, they produce apronounced strengthening effect. Only small amounts of the dispersed materials are required and on obstacle introduced into the matrix prevents adislocation from slipping unless we apply forces, and the metal be stronger. The tensile strength of 0.3% Cu /Al_20_3 composite could reach (130%) of 0.1% Al_2O_3 and hardness (138%) was obviously higher than that of pure Cu, fig (1). This is because fine, dispersive and hard particles an increase in alumina content from 0.1% to 0.3% has cause uniform increase in hardness. Fig(4) .



(a) 0.1% Al_2O_3



(b) 0.2% Al_2O_3



(c) 0.3% Al_2O_3

Fig (1) effect of Al_2O_3 on the tensile strength

2-Electrical conductivity:

The variation in electrical conductivity with respect to alumina contents in composite is shown in fig(2,3) and this shows a uniform decrease in electrical conductivity with an increase in alumina content due to the present of alumina which imparts more electron scattering. The dispersed phase is not as closely spaced as solid solution atoms nor is it coherent, as in age hardening. Thus, the effect on conductivity is small, few lattic defects to scatter electrons, the mean free path is long which have a pronounced effect on the conductivity (permits high mobilities and high conductivity) Can strongly obstruct the motion of dislocations.

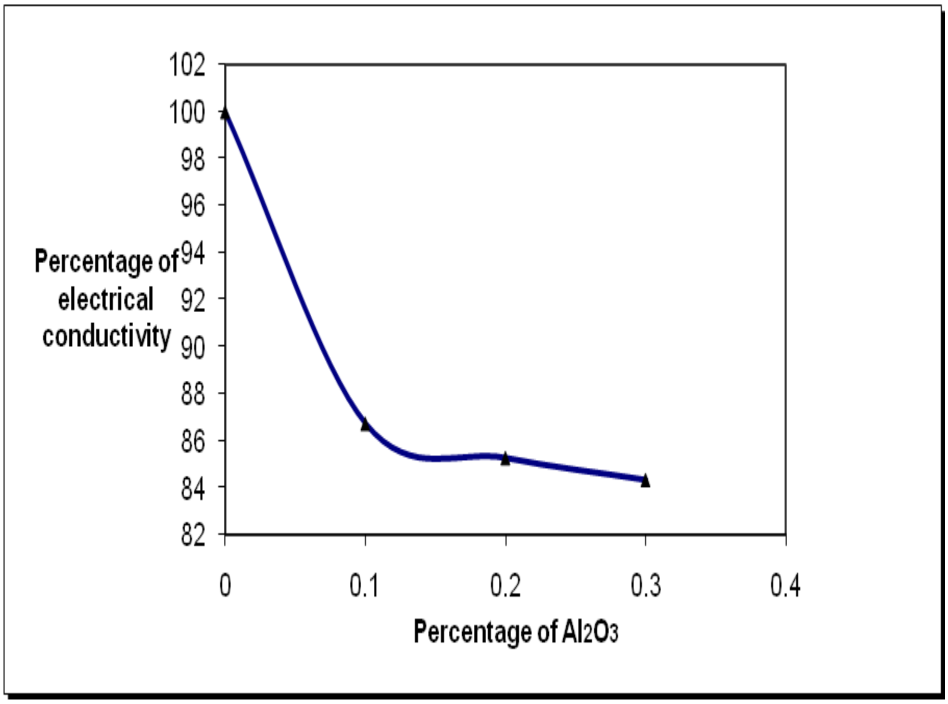


Fig (2) effect of Al_2O_3 on the percentage of electrical conductivity

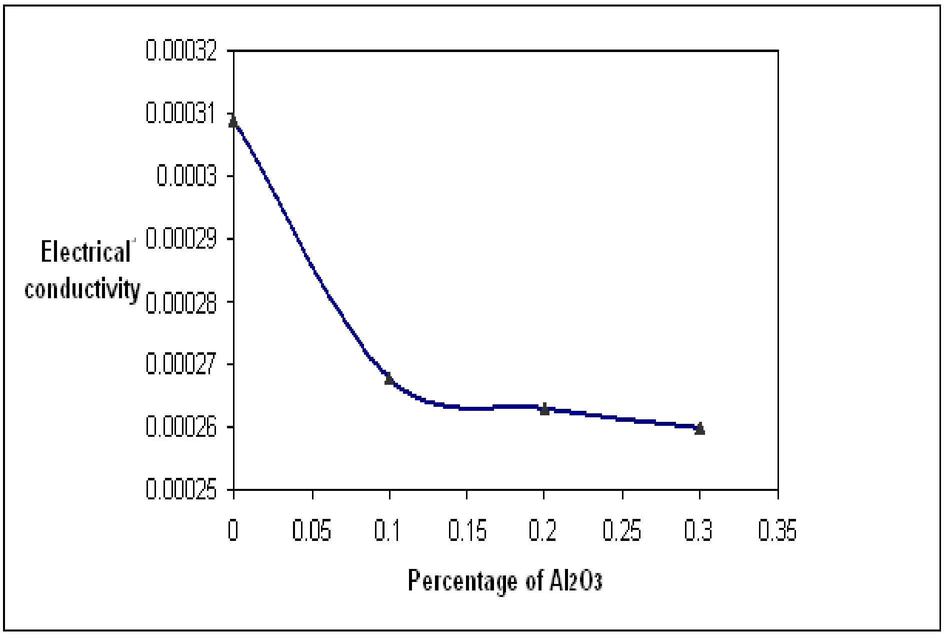


Fig (3) effect of Al_2O_3 on the electrical conductivity

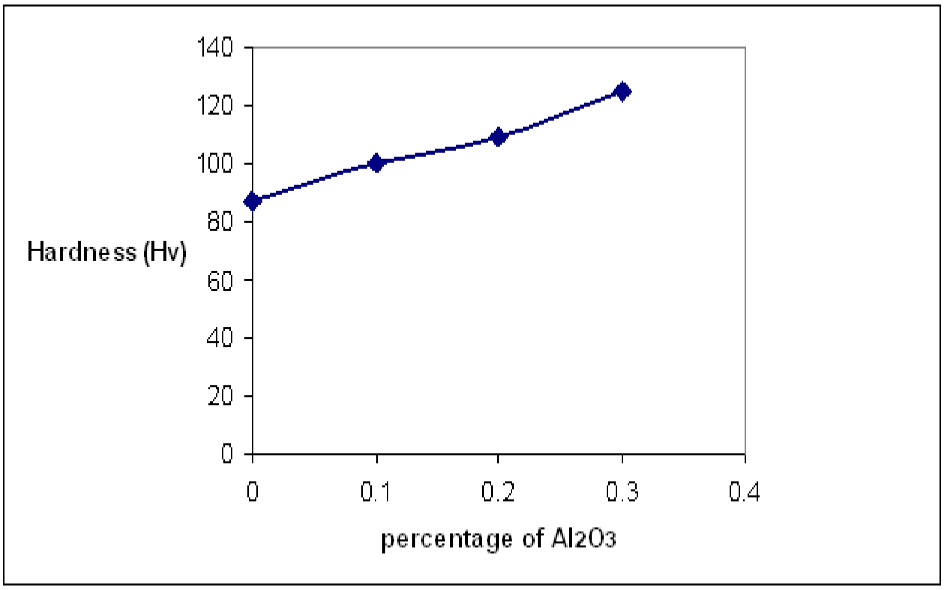
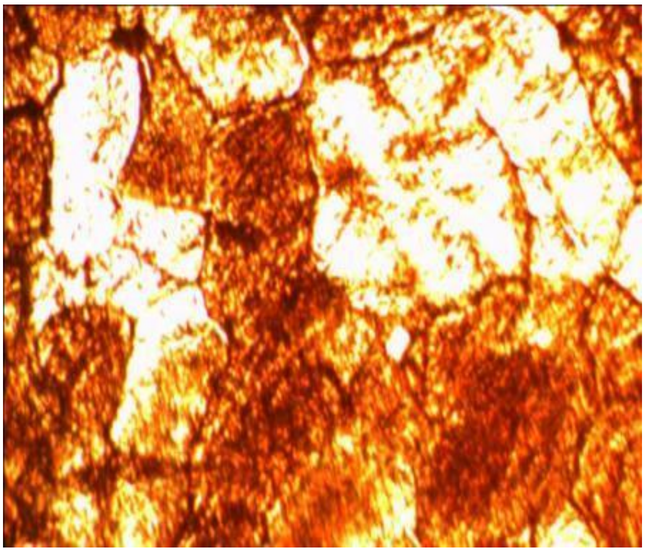
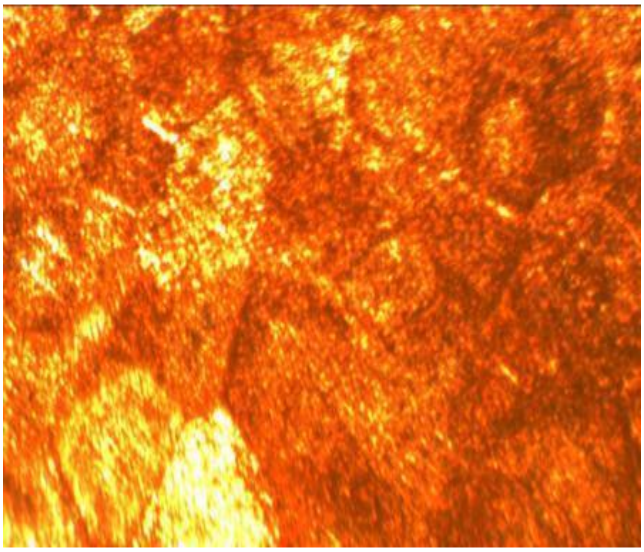


Fig (4) effect of Al_2O_3 on the hardness

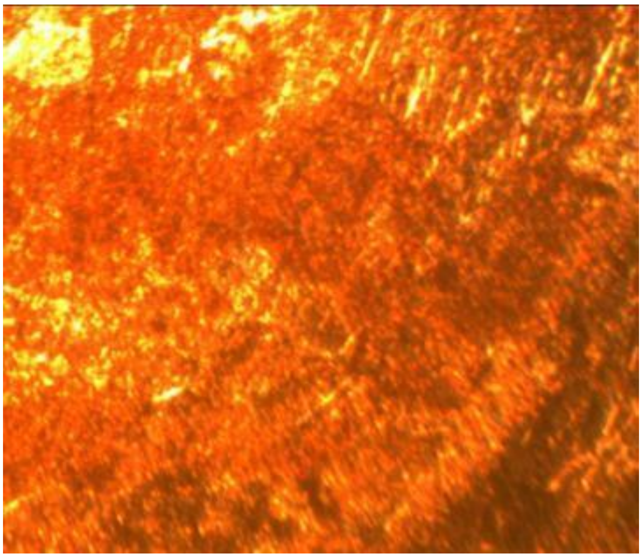
4- Microstructure

The effect adding of alumina on the shape and size of pure copper is shown in figure (5) Fig. (5a) shows the light optical microscope micrograph of pure copper without Al_2O_3 which reveal coarse particles. On the other hand Fig.5(b – d) represent the microstructures of copper inoculated with 0.1, 0.2 and 0.3 wt% Al_2O_3. By increasing of alumina percentage the particle size will be finer and the mechanical and electrical properties will be improved as compared with pure copper.

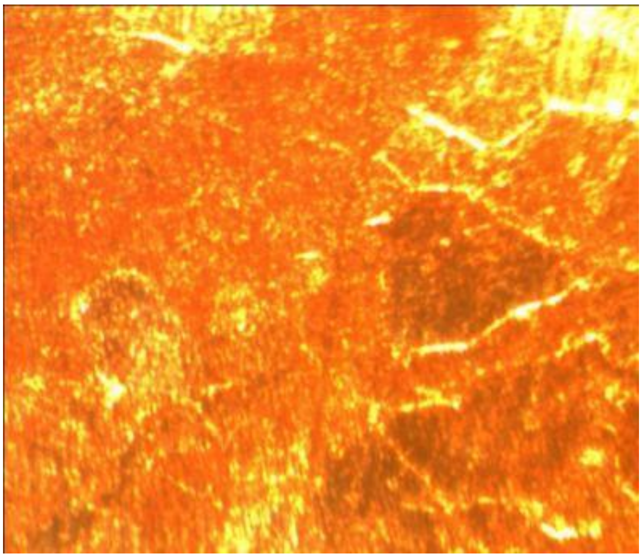




(a) copper without inoculation Al_2O_3 **(b) copper inoculated with 0.1% Al_2O_3**



(c) copper inoculated with 0.2% Al_2O_3



(d) copper inoculated with 0.3% Al_2O_3

Fig (5) microstructure of copper and Al2O3 all at magnification x200

Conclusion

- Small addition of alumina particle as reinforcement phase can balance between mechanical properties and conductivity.
- An increase in Al_2O_3 content has increased the hardness with small decreasing in the electrical conductivity.
- The tensile strength of 0.3% Cu/Al_2O_3 composite reached 130% of 0.1% Al_2O_3 and hardness 138%.
- The percentage of electrical conductivity was decrease as increasing alumina content.

References:

Groza .Joanna, 1992,"Copper matrix hardening by alumina particles". j. mater, Eng. Perform.

Hussain. Zuhailawati and Koay. H Keong, 2005, "studies on Alumina Dispersion-strengthened Copper Composites through ball milling and mechanical alloying method", jurnal Teknologi 43(A) Dis,

Miracle .Daniel B.,2001, " Metal Matrix Composites For Space System ", TMS (The Minerals, Metals and Materials Society).

Rajkovic .Viseslava , Bozic. Dusan , Stasic .Jelena and Dimcic .Biljana, 2009 , "Properties of Cu – Al_2O_3 composites obtained by high- energy milling and internal oxidation",Mjom vol 15 (3) , P.181-188.

WU. Jian jun , LI. Guobin , Zhang.Yun ,Jiang. Zhengxing,1999, "Copper Matrix Composites Reinforced with Nanometer alumina Particles", .j.mater, Sci. Technol, vol 15 , No.2.