

# Comparison of Ag and Zr with same atomic ratio in Cu-Cr alloy

**Xue Feng, Haofeng Xie, Zongwu Li, Xujun Mi, Guojie Huang, Lijun Peng, Zhen Yang and Xiangqian Yin**

State Key Laboratory of Nonferrous Metals and Process, GRIMAT Engineering Institute Co., Ltd., No.11 Xinke Dongda Str., Beijing, China  
Email: xue015@163.com

**Abstract.** In order to compare the effect of Ag and Zr with same atomic ratio on mechanical properties and electrical conductivity improvement of Cu-Cr system alloys, three alloys (CuCrZr, CuCrAg and CuCrZrAg) were prepared. And the mechanical properties and electrical conductivity during different aging process had also been studied. The results showed that the tensile strength of CuCrAg and CuCrZrAg were similar at various aging temperature better than CuCrZr. While the electrical conductivity of CuCrZr was better than others.

## 1. Introduction

Age-hardened Cu-Cr system alloys show excellent mechanical properties, high thermal and electrical conductivity, which have been widely used in the field of aviation, navigation, electric power and transportation. Ag and Zr as the third component have been widely used in Cu-Cr system alloys. The addition of Zr to Cu-Cr alloy can refine the Cr and, Zr-rich phase can increase the tensile strength in the aging process, due to the interaction between Cr and Zr element [1-4]. While Ag can improve the alloy's mechanical properties by solid solution strengthening effect but decrease the electrical conductivity slightly [5].

In order to compare the effect of Ag and Zr with same atomic ratio on mechanical properties and electrical conductivity improvement of Cu-Cr system alloys, three kinds of alloy were designed, and the regularities of mechanical properties and electrical conductivity during different aging process had also been studied.

## 2. Experimental

To understand the effects of Ag and Zr with the same atomic ratio, three alloys were designed and the nominal composition was showed in Table 1. The alloy ingots were homogenized at 850°C for 4h, and then squeezed into bars by a hot-extrusion process. The bars were solution-treated at 950°C for 1h and quenched in water. The quenched bars were cold-drawn to deformation of 30.55% respectively, and then aged from 350°C to 600°C in argon atmosphere for 3h prior to air cooling.

Tensile strength measurements were performed on MTS-810 material testing machine and the morphology of fracture was observed by FEI Quanta 200F scanning electron microscope. The electrical resistivity was determined by a micro-resistance measuring instrument. The mean value of five measurements had an estimated accuracy of less than 50μΩ.



**Table 1.** The composition of three designed alloys.

Alloy	Atomic ratio/at%	Weight ratio/wt%
A	Cu-0.3Cr-0.07Zr	Cu-0.25Cr-0.1Zr
B	Cu-0.3Cr-0.07Ag	Cu-0.25Cr-0.118Ag
C	Cu-0.3Cr-0.035Zr-0.035Ag	Cu-0.25Cr-0.05Zr-0.059Ag

### 3. Results and discussion

Figure 1 shows the morphology of three alloys before and after cold-drawn. When the alloys were solution-treated at 950°C for 1h, recrystallization happens and the equiaxed grains with average size of 40-100µm are obtained (Figure 1(a)-(c)). While after cold deformation, the average size declines to 5-20µm (Figure 1(d)-(f)).

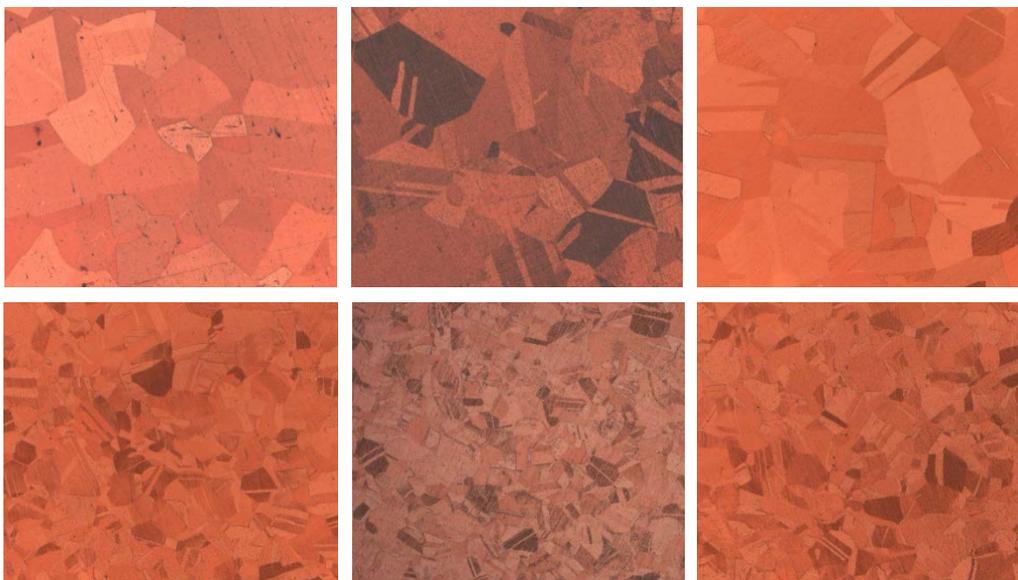
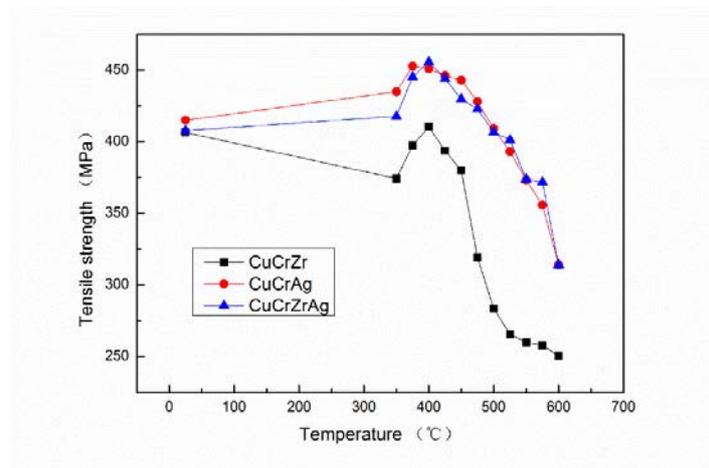
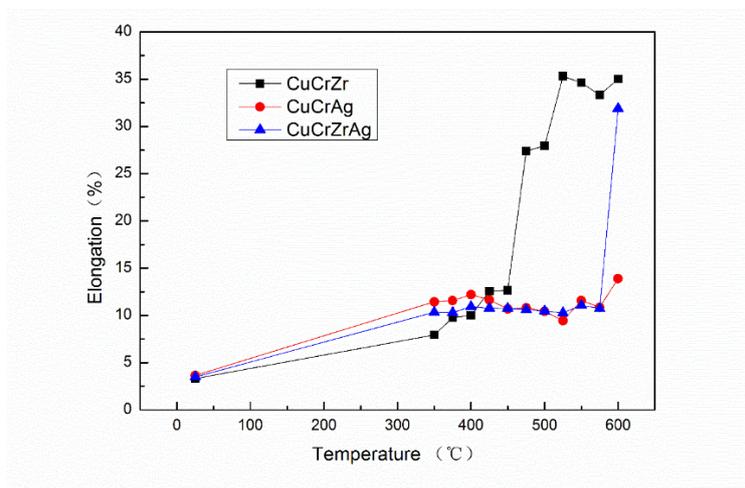
**Figure 1.** The morphology of three alloys before and after cold-drawn

Figure 2 shows the effect of aging temperature on tensile strength of CuCrZr, CuCrAg and CuCrZrAg. It can be seen that with the increase of aging temperature, the tensile strength of CuCrAg and CuCrZrAg rises initially and then drops dramatically, reaching the maximum value at 400°C. While the tensile strength of CuCrZr increases after a slight decrease, and then declines remarkably. And the tensile strength of CuCrZrAg and CuCrAg is similar to each other reaching about 450MPa after aged at 400°C, which is better than that of CuCrZr (about 410MPa). When the aging temperature below 350°C, the effect of precipitation strengthening is lower than the effect of relief annealing, thus a slight decrease happens to the CuCrZr, while the Ag element which solid soluted in matrix could compensate for the stress drop. Further increasing the aging temperature, the morphology and distribution of precipitates as well as the relationship with matrix play the important roles on tensile strength, which have been discussed in our previous work [6].

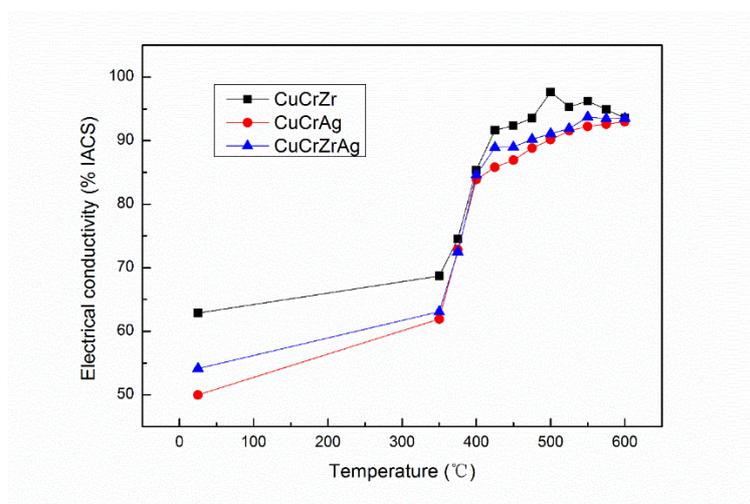
Figure 3 shows the effect of aging temperature on elongation of CuCrZr, CuCrAg and CuCrZrAg. With the increase of aging temperature, the elongation rises. When the aging temperature reaching to 400°C, the elongation of three alloys are all around 10%. And an abrupt rise happened to CuCrZr may be due to more continuous matrix existing after high temperature aging.



**Figure 2.** The effect of aging temperature on tensile strength of CuCrZr, CuCrAg and CuCrZrAg



**Figure 3.** The effect of aging temperature on elongation of CuCrZr, CuCrAg and CuCrZrAg



**Figure 4.** The effect of aging temperature on electrical conductivity of CuCrZr, CuCrAg and CuCrZrAg

Figure 4 shows the effect of aging temperature on electrical conductivity of CuCrZr, CuCrAg and CuCrZrAg. The electrical conductivity of CuCrAg and CuCrZrAg increase with rising the aging temperature. While the electrical conductivity of CuCrZr increases initially and then declines, reaching the maximum (97%IACS) at 500 °C. And the electrical conductivity of CuCrZrAg is better than CuCrAg but lower than CuCrZr. In CuCrZr, precipitation strengthen is the main mechanism, so with the exsolution of precipitation, the effect of lattice distortion on electron scattering becomes lower. While in CuCrZrAg and CuCrAg, precipitation strengthen and solution strengthen play the combined action, Ag element still dissolved in the matrix during aging process reducing the increasing of electrical conductivity.

#### 4. Conclusion

In this work, CuCrZr, CuCrAg and CuCrZrAg with the same atomic ratio (Ag+Zr) were prepared to compare the effect of Ag and Zr. The results of mechanical properties showed that CuCrAg and CuCrZrAg had better tensile strength reaching about 450MPa after aging at 400 °C. While the highest electrical conductivity (97%IACS) were obtained in CuCrZr after aging at 500 °C for 3h.

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