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(RESEARCH ARTICLE)

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Investigating the impact of Nano Cu at different weight percentages on the electrical conductivity of aluminum wire

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Abstract

This research focuses on effects of three different nano cu on Aluminum wire to study the electrical conductivity pattern in those composite wires. The need for enhancing the electrical conductivity of materials has led to innovative approaches such as the incorporation of nanoscience into metal matrices. In this study, the effects of nano copper (Cu) at three different weight percentages (1%, 2%, and 3%) on the electrical conductivity of aluminum wire were studied carefully. Nano cu had an average of 150 nanometer nm length with 99.8 purity. Understanding these effects is crucial for advancing the development of high-performance conductive materials for various applications, including electronics and power transmission.

Keywords: Aluminum based; Electrical conductivity; Nano Cu; Weight percentage; Experimental study

1. Introduction

In the realm of materials science and engineering, the pursuit of enhanced electrical conductivity stands as a fundamental objective driving innovation across industries [1-3]. From the intricate circuitry of electronic devices to the vast networks of power transmission lines, the demand for materials with superior conductivity properties continues to grow [3-5]. Aluminum (Al) has long been revered for its commendable conductivity, making it a cornerstone in numerous applications. However, as technological advancements push the boundaries of efficiency and performance, the quest for materials with even higher conductivity and additional desirable traits persists. Different nano-sized copper particles (Cu) and their integration into aluminum matrices, heralding a new era in composite materials with unparalleled electrical conductivity [6-9]. This synergy between aluminum and nano Cu represents a paradigm shift, promising not only enhanced conductivity but also a host of other benefits. At the heart of this innovation lies a deep understanding of the intricate interplay between material structure, electron behavior, and interface dynamics [10-12].

The pursuit of improved electrical conductivity is not merely an academic endeavor but a quest with profound implications for various industries. The integration of nano Cu particles into aluminum matrices holds the potential to revolutionize electrical wiring systems, power transmission networks, electronic devices, and renewable energy technologies. By delving into the mechanisms underlying the enhanced conductivity of nano Cu-Al composites, researchers and engineers are paving the way for transformative advancements that will shape the technological landscape for generations to come [13-15].

This paper embarks on a journey to unravel the mysteries of electrical conductivity enhancement through nano Cu addition in aluminum composites. Through an exploration of fundamental principles, cutting-edge research findings, and potential applications, we aim to illuminate the path towards harnessing the full potential of nano Cu-Al composites.

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From the intricacies of electron mobility to the fascinating world of quantum size effects, each facet of this composite material holds promise for unlocking new frontiers in conductivity engineering.

As we delve deeper into the realm of nano Cu-Al composites, it becomes evident that their impact extends far beyond the confines of laboratory experiments and theoretical models. These materials have the power to revolutionize industries, transform technologies, and reshape the future of electrical conductivity. With each breakthrough in our understanding of nano Cu-Al composites, we inch closer to a world where conductivity knows no bounds, powering innovations that propel humanity towards a brighter, more electrifying tomorrow

Aluminum is widely used in electrical applications due to its excellent conductivity and lightweight properties. However, efforts to further improve its conductivity have led researchers to investigate the potential of incorporating nanoparticles such as copper into aluminum matrices. Nano Cu particles have shown promise in enhancing the electrical and mechanical properties of aluminum-based materials due to their high surface area-to-volume ratio and superior electrical conductivity.

2. Experimental Procedure

In this study, aluminum bars were prepared using the powder metallurgy method, with nano Cu particles incorporated at three different weight percentages: 1%, 2%, and 3%. The blending method was sparking plasma sintering method. The most important thing at this mixture was uniform dispersion of nano Cu in Al matrix. Therefore, to ensure that this mixture is completely homogenous, TEM microstructure photos were taken as shown in figure 1 and figure 2. By drilling down into picture 1, nano cu dispersed uniformly on the Aluminum wires. Then it is the proper time for novel wires to be subjected to various tests to evaluate their electrical conductivity. Map of cu nanomaterial at 3 wight percentage is shown in figure 3. It is quite clear that this map can easily be used as a sign of uniform dispersion of nano Cu.

Then Aluminum wire without cu, and with 1,2, and 3 weight percentage were tested in conductivity measurement instrument shown at figure 4.

Figure 1 SEM instrument for electron microscope used for this research

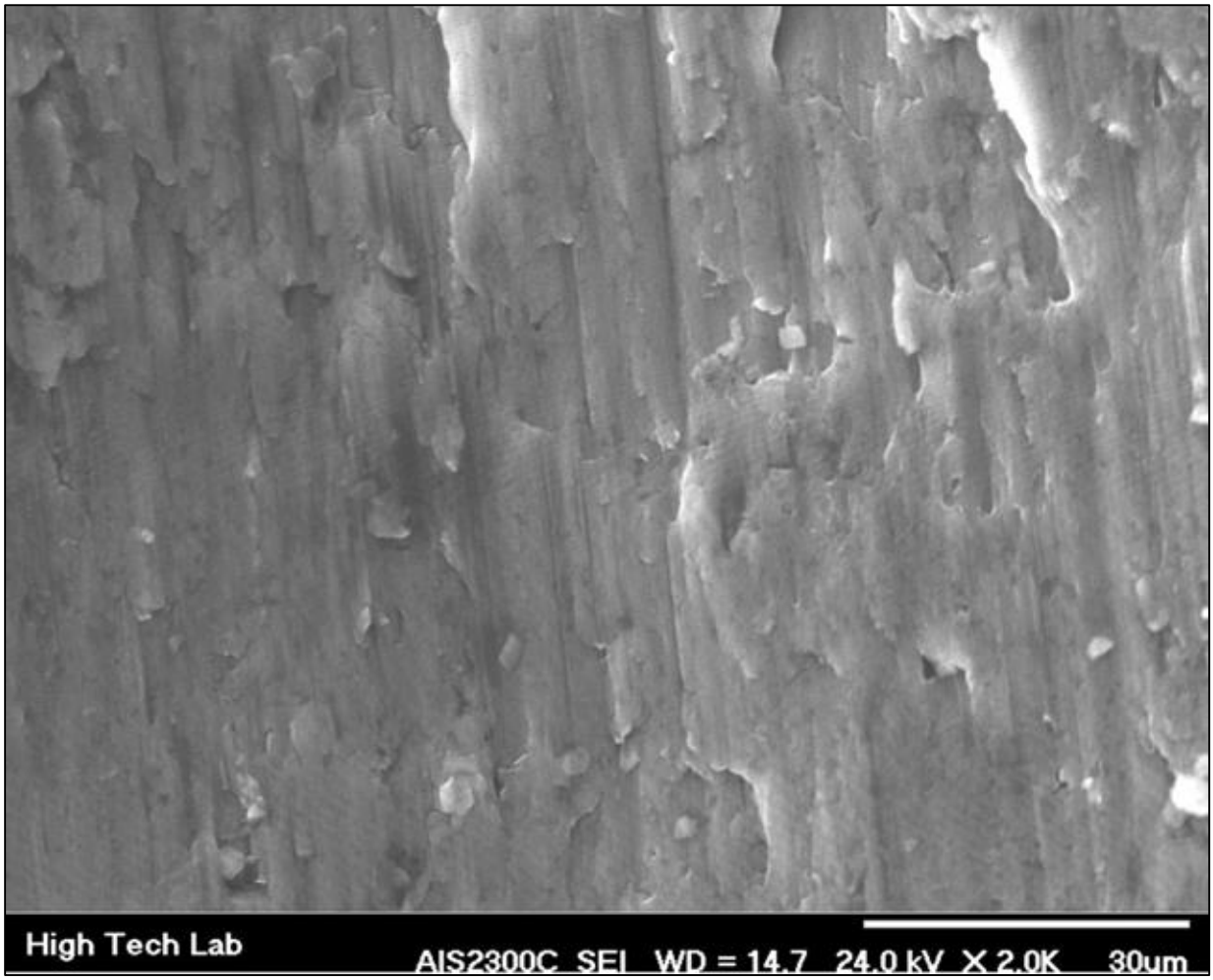

Figure 2 Nano cu dispraised uniformly in the matrix

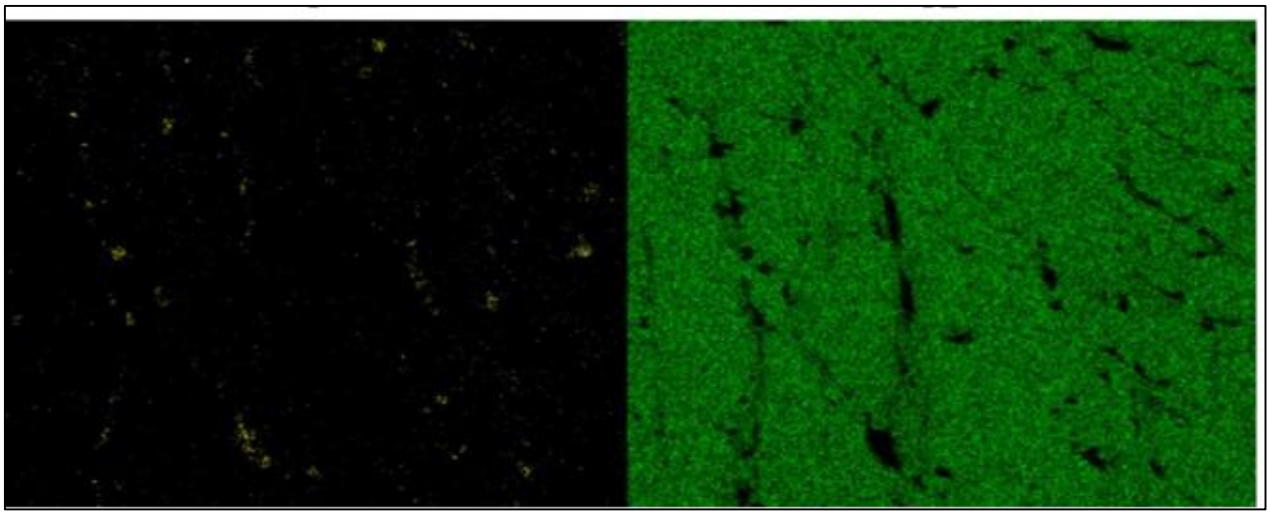

Figure 3 Nano cu map (left side) and Aluminum map (right side)

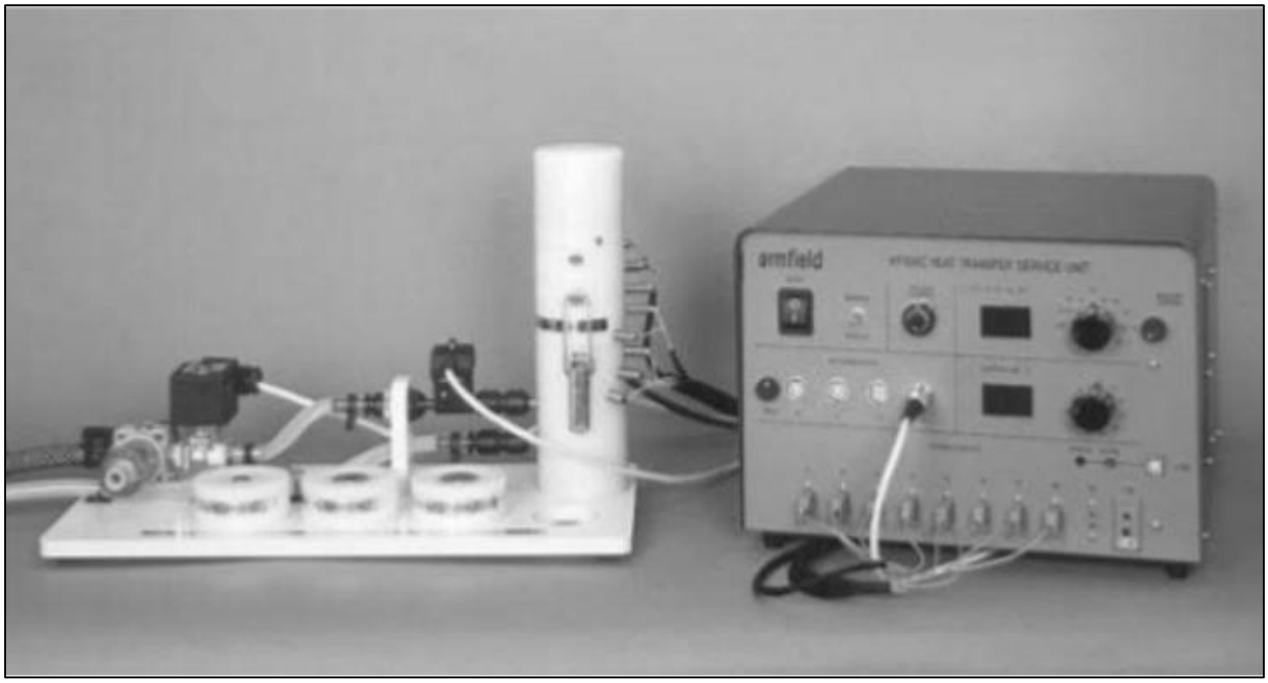

Figure 4 Electrical Conductivity measurement set up at this research

3. Results and Discussion

The electrical conductivity of these wires was measured carefully, and results are shown in table 1. One can find there is no linear pattern between weight percentage of nano Cu and increasing electrical conductivity of them.

Table 1 Electrical conductivity of Aluminum wire with and without nano Cu

Sample	Electrical conductivity
Al	37×10^{6} s/m
Al + 1% 150 nm Cu	39.6×10^{6} s/m
Al + 2% 150 nm Cu	45.3×10^{6} s/m
Al + 3% 150 nm Cu	40.3×10^{6} s/m

The results of the experiment revealed a significant impact of nano Cu on the electrical conductivity of the aluminum wire. At lower weight percentages (1% and 2%), the addition of nano Cu led to a gradual improvement in conductivity compared to the pure aluminum wire. This enhancement can be attributed to the formation of conductive pathways facilitated by the dispersed nano Cu particles within the aluminum matrix.

The electrical conductivity of aluminum wires was investigated by incorporating varying weight percentages of nano-sized copper particles, each with a length of 150 nm. Three different weight percentages of copper, labeled as 1, 2, and 3, were examined. The results revealed that among the tested weight percentages, the wire containing 2 weight percentage of nano copper exhibited the highest electrical conductivity compared to the wires with 1 and 3 weight percentages. This outcome suggests that the addition of nano-sized copper particles at an optimal weight percentage enhances the electrical conductivity of the aluminum wire. The findings underscore the potential of nano copper as a promising additive for improving the electrical properties of aluminum-based materials, offering insights for future developments in electrical conductivity enhancement techniques

However, at higher weight percentages (3%), a decrease in electrical conductivity was observed. This phenomenon can be attributed to the agglomeration of nano Cu particles, which disrupts the uniform distribution of conductive pathways and increases the scattering of electrons within the composite wire.

4. Conclusion

In conclusion, the incorporation of nano Cu at different weight percentages has a notable impact on the electrical conductivity of aluminum wire. While lower weight percentages can enhance conductivity by promoting the formation of conductive pathways, higher percentages may lead to a decrease in conductivity due to particle agglomeration. These findings contribute to the ongoing research efforts aimed at optimizing the electrical properties of composite materials for various industrial applications.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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