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Study on Preparation of Copper Nanoparticles by Spark Erosion

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Abstract: **According to the principle of EDM proposes a method for preparing copper nano-particles. With copper as a raw material in deionized water for EDM, and the product was isolated and purified. On this basis! By SEM and EDS purified product was analyzed in detail, the results showed copper nanoparticles diameter of about 30nm, and even its size, through theoretical analysis and experimental comparison, preliminary study of the origin and formation of nanoparticles.**

Keywords: **EDM, nano-particles of copper, deionized water, copper.**

1. INTRODUCTION

Nano is an optical microscope unobservable scales, "their scale is generally <100nm. When reducing the size of the material to the nanometer scale, the will have some special properties," such as surface effect (volume effect and quantum effects, etc. "Therefore," in recent years related to Preparation of (properties and applications of nano materials has been the hot research[1] and copper nanoparticles specific surface area is large (more than the number of surface active centers, has been metallurgy (petroleum and other chemical industries in good catalyst; at the same time, nano Copper can also be used as a solid lubricant, which can combine with the solid surface, forming a smooth layer of protection, "capable of filling the micro-scratch, so as to effectively reduce friction and wear [2-3]. In the electrical industry, when the copper nanoparticles added non-conductive insulating oils, non-conductive grease to make the original becomes conductive grease, and then be used for high current electrical contacts and high current knife switch [4].

Currently, the preparation of copper nano particles is done mainly by gas, liquid and solid phase method. Gas-phase method is the direct use of gas or through various means will become gaseous substances, so that the biological material in the gaseous state is issued.

Physical changes or chemical reactions "grow form nanoparticles method ultimately collected in the cooling process; gas law can be divided into a gas evaporation method (chemical vapor reaction (chemical vapor condensation method (a sputtering method, etc. [5] liquid phase. method [6-7] is a method for preparing ultrafine laboratories and industry is widely used at present, the process is as follows: Select one or more suitable soluble metal salts, measuring material composition prepared by the preparation of a solution, so that all the elements were ion or molecule state; then select an appropriate precipitating agent or with a reducing (hydrolysis operation, the metal ion precipitation or even crystallized; Finally, precipitation or crystals dehydration or heat decomposition obtained ultrafine. solid phase method [8-9] is a traditional chalking process to change from the solid phase by the solid phase to produce powder, used for coarse particles fine; its micronized mechanism can be divided into two categories: The class is divided chunks fine substance, namely the method (ball mill) to reduce the size of the process; the other is the smallest unit (molecules or atoms) in combination, namely to build a process approach (mechanical chemical method).

Based on the principle of EDM material removal, a new method for preparing copper nanoparticles ----- EDM Preparation of copper nanoparticles. In the preparation process, in order to obtain high purity copper to copper as the material of the workpiece and the electrode; meanwhile, in order to effectively reduce the occurrence of electrolysis, a high speed flow of deionized water as working fluid. Finally, SEM and EDS processing products were analyzed.

Solution using fresh deionized water, while taking advantage of high-speed punch was so extreme between the working fluid and constantly updated to avoid electrolysis phenomenon.

Table 1 shows the preparation conditions of # by conventional processing discharge pulse width (20 µs) and short pulse width (1 µs)

Preparation of copper nanoparticles were conducted. After the processing is completed # required product was isolated and purified # steps shown in Figure 2.

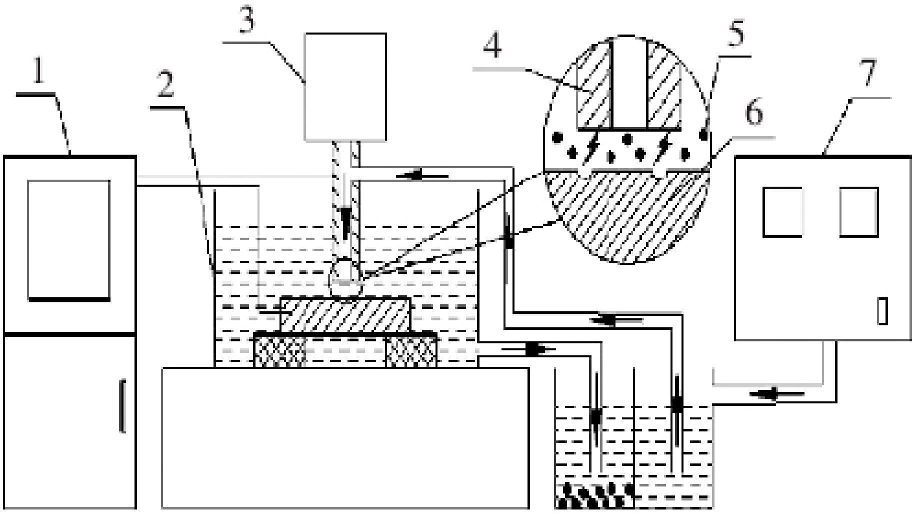

Figure 1: nanometer copper particle powder preparation system

2. THE TEST APPARATUS AND PROCEDURE

Copper Nanoparticles Preparation system shown in Figure 1 # during preparation working

1. The power supply and control systems

2. Work tank

3. The feed device

4.The tool electrode

5. The product particles

6. Workpiece electrode

7. deionized water preparation equipment

Table 1: nanometer copper particle powder preparation conditions

project	Value or condition
Tool electrode	Copper diameter of 1mm
Workpiece electrode	Copper ingots # size 10cmx20cmx20cm
Processing polar	Negative processing
Working fluid	Deionized water,conductivity 0.1µs / cm
Open circuit voltage / V	150
Peak current / A	13

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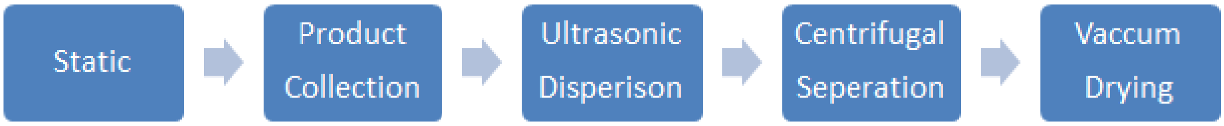
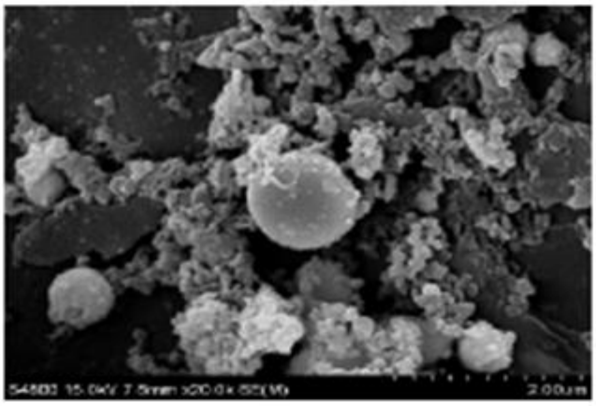


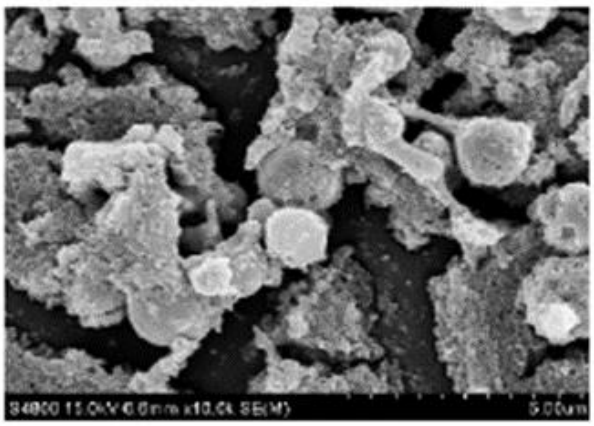
When processing, in order to ensure the working fluid has a low resistivity, thus avoiding electrolysis and it can be recycled, it is less the product of the working fluid content in the processed. To facilitate collection # need to stand the working fluid for some time, usually 12h. When all the processed products are precipitated to the bottom of the container, the removal of the upper layer of clear liquid, you can get the product, however, processed products will inevitably contain particles of various sizes, in order to obtain nanoscale copper particles, the product needs to be Further purification, firstly, the use of ultrasonic vibrations the particles are uniformly dispersed in the solution; secondly, high-speed centrifuge, under 3000r / min speed, the product was classified; Finally, the product classification after drying in a vacuum oven dry, thereby obtaining the desired copper **.**

3. RESULTS AND DISCUSSION

Powder obtained by SEM of the test results shown in Figure 3 Figure #, # # may prove effective isolation of the product can be achieved by way of centrifugation. At the same time it can be seen, when the powder is 20 μs pulse width is obtained, although a small amount of submicron particles, but most particle diameter of about 100nm; and a pulse width of 1 μs under conditions to produce a particle diameter of about 300nm # and evenly distributed.



a) after purification of the product when the pulse width 20 μs SEM image



b) the purified product when SEM image width 1μs

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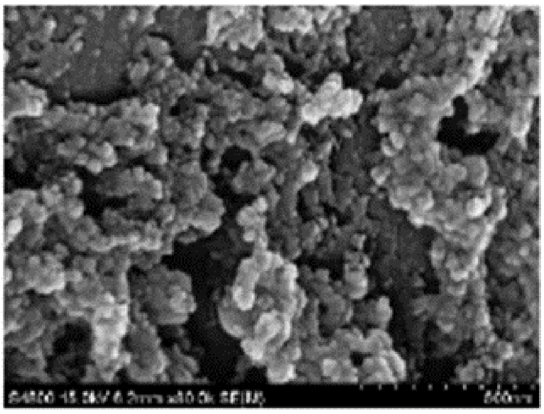

c) when the pulse width 1μs after the product was purified SEM image (enlarged)

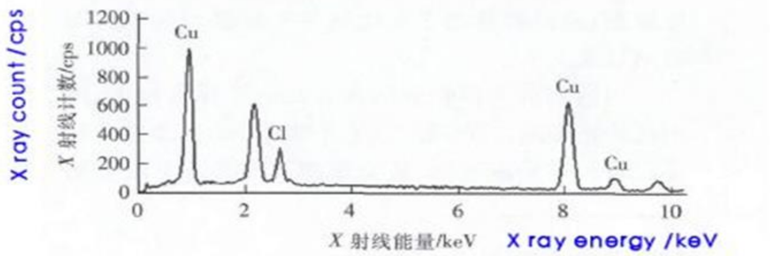

图 4 EDS 图片
EDS pic

4. PRODUCT SEM IMAGE

At the same time, the use of EDS analysis of its components. Figure -4 shown by the EDS image comprising a plurality of peaks can be found in copper, indicating that the powder contained in a variety of forms of copper # but most elemental composition of copper, by the nature of the experiment copper and copper nanoparticles seen # susceptible to oxidation during the preparation, to generate cupric oxide and cuprous oxide, during the preparation of the test sample, to remove copper oxide and a small amount of hydrochloric acid was added to samples # therefore also contain minor amounts of chloride ions.

Use Ansys, the temperature field simulation #, when the pulse width of 20 μs, the maximum temperature of the workpiece material is less than 2495K copper gasification temperature (2893K); and when the pulse width is reduced to 1μs, the highest temperature up to 5924K (Figure 5). Thus, the formation process and mechanism nanoscale particles are different.

(a)脉宽 20 μs 时的温度场分布 Pulse Width 20 when the Temperature Field distribution

(b)脉宽 1 μs 时的温度场分布 Pulse Width 1 when the Temperature Field distribution

图 5 Ansys 仿真温度场分布 Ansys simulation temperature Field distribution

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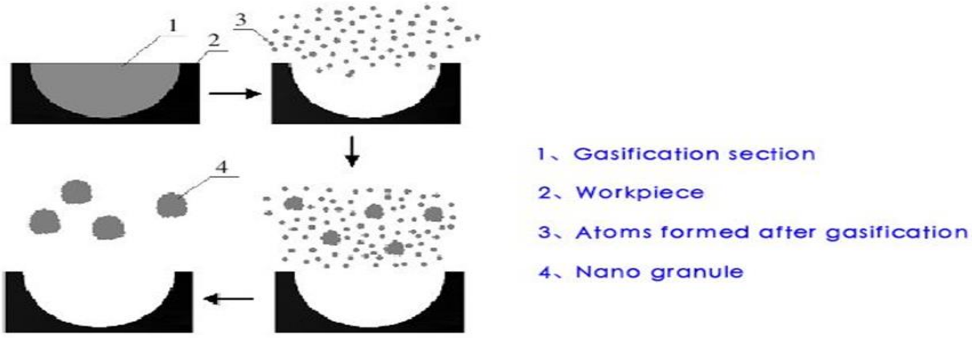
When the pulse width is large, the removal of all material is melted by the material, in a variety of splashing into the work force of the medium, in this process may produce a small amount of nano-particles; when the pulse width is reduced, the workpiece part of the material will be gasification, gasification part in the form of atoms or clusters away from the workpiece into the working medium # however, very unstable atoms or clusters, they will work with its neighboring atoms or clusters attract each other and form a nano particles, this process occurs in a very short period of time, the process shown in Figure 6. At the same time, by experiment further found that the content of the nanoparticles under conditions far less than the large width of nano particle content small pulse conditions.



1. 气化部分 2. 工件 3. 气化后形成的原子 4. 纳米颗粒

图 6 纳米颗粒形成过程

Nano granule formation process

In order to further increase the yield of nanometer particles of copper, the key is to increase the proportion of gasification and gasification volume. The discharge process of gasification process is determined by the power density, power density is calculated according to P and the discharge channel radius R can be obtained [10]:

$$P = \frac{iu}{\pi r^2}$$

$$R = 2.01\ x\ 10^{-3} i^{0.43} t^{0.44}$$

$$P = i^{0.14}(4.041x10^{-6})t^{0.88\pi}$$

Where: i is the discharge sustaining current; t is the pulse width.

(3) shows that the power density decreases as the discharge increases to maintain current and pulse width increases, but the discharge radius increases with the discharge sustain current and pulse width increases. Therefore, in order to efficiently obtain nanometer copper particles, you must select the appropriate discharge maintaining current conditions, to minimize the pulse width.

5. CONCLUSIONS

By analyzing the product under different discharge pulse conditions, combined with EDM theory, discusses the sources of nano-copper particles and the formation process, the following conclusions:

1) The way to achieve effective EDM nano copper particles with a diameter of about 30nm nanoparticles and the size is very uniform, but in the process of preparation and holding prone to oxidation.

2) Material EDM removal process is mainly through the high temperature of the workpiece material is melted or vaporized, however, the source of the nanoparticles after which the gasification part # material is gasified in the form of atoms or clusters into the working medium and mutual attraction with adjacent atom or clusters and gradually cooled and solidified, thereby forming the nanoparticles.

3) For the efficient obtain nanometer copper particles, parameter settings should be in both the efficiency and the need to minimize the pulse width to increase the power density, thereby increasing the proportion of gasification.

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