ABSTRACT

The main purposes of the PhD. thesis researches are: the elaboration of some nanocomposites materials with tungsten nanopowders matrix used for the fabrication of the electrical contacts for high voltage current and the elaboration of optimal fabrication technologies for the fabrication of the materials and electrical contacts by powder metallurgy technique.

The fallowing objects were:

- The elaboration and the characterization of tungsten nanopowders obtained by mechanical milling in a high energy ball mill;
- The elaboration and characterization of W-Cu nanostructured materials by mechanical alloying technique;
- The study of the mechanical alloying parameters of the tungsten nanopowders and copper powders using two working types of the planetary ball mill: friction mode şi shock mode;
- Using of a new process of sintering as two step sintering for the elaboration of the W-Cu nanostructured electrical contacts;
- Structural characterization of the W-Cu nanostructured electrical contacts;
- Characterization of the nanostructured electrical contacts by electrical properties view;
- Characterization of the nanostructured electrical contacts by tribological properties view;
- The interaction study between nanometric structure and the functional properties of the nanostructured contacts.

To attend these objects three types of materials from W-Cu system with different concentration such as: 85W-15Cu, 80W-20Cu, 75W-25Cu were analyzed.

For the beginning the tungsten nanopowders were elaborated by mechanical mill using a Pulverisette 4 vario-planetary ball mill made by Fritsch. The resulting tungsten nanopowders were mechanically alloyed with micron copper powders.

Two types of mechanical alloying technique were used: shock mode and friction mode.

The working parameters for the mechanical milling and alloying were established, the pressure and the temperature inside of milling bowls being measured with an GTM system made by Fritsch for all the working period.

The tungsten nanopowders after mechanical milling and W-Cu nanocomposite powders were analyzed by electronic microscopy SEM, energy dispersive x-ray analysis EDAX and particle size distribution.

The following conclusions were:

- It is observed that after 10 hours of mechanical milling the tungsten powder is in the nanometric scale with a maximum of the particle size in the range of [121.6; 150.2] nm. Between 10 and 20 hours it is observed that the particle size decrease with the increasing of the milling time and after 20 hours the particle size being in the range of [73.2; 88.3] nm;
- From particle size view the best results were obtained for the mixtures elaborated by friction mode comparative with shock mode;
- The smaller particle size distribution were attained for the 80W-20Cu elaborated by 8 hours of mechanical alloying;
- From SEM analyses it is observed that the particles are agglomerated specially at higher times of mechanical alloying. The difference between copper particles and tungsten particles it is observed too;
- The shape for all the three samples obtained after 8 hours of mechanical alloying by friction mode respectively shock mode is irregular.

In chapter 3 the influence of the compaction and sintering parameters to the green densities, volumes contraction, densities after sintering respectively porosity and microstructure of the electrical contacts were studied.

The influence of the following parameters:

- Mechanical alloying time;
- Mechanical alloying mode: shock respectively friction;
- Copper content;
- Type of sintering (classic and two step sintering);
- Maintaining time for 2 respectively 8 hours at the sintering temperature

to the electrical contacts properties has been studied.

By the experimental work the following conclusions are:

- The green densities of the samples obtained by friction mode are higher than the green densities of the samples obtained by shock mode;
- After 6 and 8 hours of mechanical alloying the lower green densities were attained for the samples with 25% copper;

- The densities after two step sintering are dependent by the maintaining time at the sintering temperature. The densities of the samples obtained after 8 hours of maintaining at the sintering temperature (1080 ^{o}C) are bigger than the samples obtained after 2 hours of maintaining at the same sintering temperature;
- The densities of the samples after the classic sintering are in the range of [12-13] g/cm^3;
- At the two step sintering process the best values of the densities were attained for the samples obtained by friction mode mechanical alloying time for 6 and 8 hours and maintaining at the sintering temperature for 8 hours.

In chapter 4 the electrical contacts obtained by nanocomposite powders were characterized by electrical and mechanical properties resulting the following conclusions:

- Uniform values of the electrical parameters were attained for the W-Cu nanostructured contacts obtained by friction mode mechanical alloying;
- Optimal values of the electrical and mechanical parameters were attained for the W-Cu nanostructured contacts obtained by friction mode mechanical alloying;
- Higher values for the electrical conductivities were obtained for the W-Cu nanostructured contacts obtained by classic sintering;
- The two step sintering at 1080 ^{o}C with maintaining for 8 hours at the sintering temperature play a good role to the increasing of the electrical resistance of the W-Cu nanostructured contacts;
- Regarding the friction coefficient the friction mode respectively the shock mode doesn't influence its values;
- The best values for the friction coefficient is 0.116 and the wear rate is 0,428 [mm^3/N/m]*10^{-2} and the nanostructured material with these properties is the alloy 75W-25Cu obtained by shock mode mechanical alloying and two step sintering with a maintaining of 8 hours to the sintering temperature;
- It is observed that the 75W-25Cu nanostructured material have the optimal electrical and tribological properties.

The main contributions of the author to the PhD. thesis are:

- The elaboration and the characterization of tungsten nanopowders obtained by mechanical milling in a high energy ball mill;

- The elaboration and characterization of W-Cu nanostructured materials by mechanical alloying technique;
- The study of the mechanical alloying parameters of the tungsten nanopowders and copper powders using two working types of the planetary ball mill: friction mode și shock mode;
- Using of a new process of sintering as two step sintering for the elaboration of the W-Cu nanostructured electrical contacts;
- Structural characterization of the W-Cu nanostructured electrical contacts;
- Characterization of the nanostructured electrical contacts by electrical properties view;
- Characterization of the nanostructured electrical contacts by tribological properties view;
- The interaction study between nanometric structure and the functional properties of the nanostructured contacts;
- Identification of the nanostructured material 75W-25Cu with optimal electrical and tribological characteristics;
- Set up the best process for the elaboration of the nanocomposite materials is the mechanical alloying by friction mode during 8 hours;
- Set up the optimal sintering process of the nanostructured composites by two step sintering with maintaining at the sintering temperature for 8 hours.