# High-Strength Submycrocrystalline Electrotechnical Bronzes Obtained with the Use of Mechanically Alloyed Nanostructured Modifying Ligatures

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In the production of low alloy copper materials the specific volume of the chrome-bearing bronzes is more 60 %. About 90 % of them account for alloys of “Cu – Cr” and “Cu – Cr – Zr” systems. They are widely used for the manufacture of both small and large-tonnage structures: heat-exchange units, including crystallizers, electrodes of contact, seam and projection welding; machine armatures using contact and resistance welding; the current supply tips; discontinuous contacts, etc.

Specific features of manufacturing chrome-bearing bronzes relate primarily to their melting and molding and are determined by the following factors: the presence of elements similar to oxygen (Zr, Ti, V, Nb, Cr, Si) in the alloy, a small allowance for alloying (sometimes ± 0,003 %), high purity requirements to the material. Therefore it is necessary to use separately prepared double and complex ligatures as a charge. This results in the high cost of bronze and environmental pollution.

Large-scale research carried out by the authors of the paper reveals that one of the promising methods for solving the problem is to use the reaction of mechanical alloying, excluding high temperature melting from the technological process of production.

The mechanical alloying includes treatment of the powder charge of the given composition in the high-energy mill, mechanoreactor, the resulting product of which is a granular composition with the sub-/mycrocrystaline basis, strengthened, as a rule , by nano-, submicro- / sized inclusions. The given structure is stable and in most cases is inherited by compact materials produced from mechanically alloyed compositions. It allows a conclusion on their application prospects in a number of cases as modifiers to be made.

A great advantage of the technology is that the use of mechanically alloyed alloys with submycrocrystalline distribution of alloying elements leads to their subsequent rapid dissolution in the copper melt. This reduces the temperature of the basic melting by 150-200 ° and shortens its duration by 2-4 times, it also decreases the loss of alloying elements at least by 1.8 times and improves the sustainability of the whole process. Besides, the technology allows smelting chrome-bearing bronzes in practically any melting units that ensure the necessary temperature conditions. The following pressure and thermomechanical treatment of bronze pilot samples is conducted in accordance with the standard technology. The typical structures of cast chromium and chronium-zirconium bronzes are shown in Figure 1.

Bronzes obtained with the use of mechanically alloyed ligatures have high density, are nonporous and don’t have microinclusions. Along with its main purpose (alloying), the developed ligatures also act as a modifier. Their fine structure is inherited by cast bronzes. The average size of the bronze grain basis is less than 1 micron , and their structure relates to the submycrocrystaline type. The alloying elements are uniformly distributed in the base. The strengthening phases after heat treatment are Cr, Zr, and probably, $Cu_3Zr$. The size of the strengthening phases does not exceed 0.1 mm and they are considered nanocrystalline. The changes in the structure have a positive effect on the properties of materials and they possess the following set of physical and mechanical properties: hardness - HB160 - 180, tensile strength - 500-600 MPa, tensile strain - 20-25 %, electrical conductivity - 80-82 % of the electrical conductivity of copper. In this case, the recrystallization temperature is 50-80° C higher than the recrystallization temperature of the similar bronzes obtained in a conventional way.

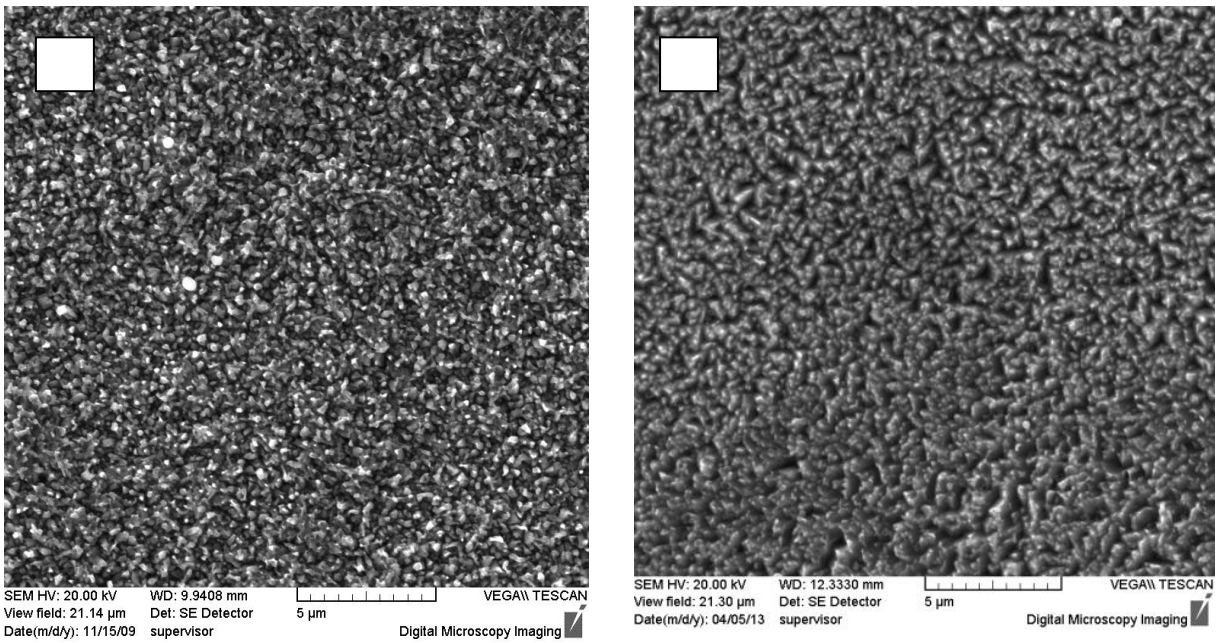


Figure 1 – Structure of chronium-zirconium (a) and chromium (b) bronze

The production tests of contact spot welding electrodes made of alloys using the developed technology were conducted at a number of leading enterprises of the Republic of Belarus ("MAZ", JSC "BelAZ", RUE "MTW", RUE "Mogilevliftmash " and others). They showed the excess of relative resistance by 1.8-2.2 times compared to counterparts in industry today.

The development of the "Technology of obtaining mechanically alloyed nanostructured modifying ligatures for the production of high-strength submycrocrystaline electrotechnical bronzes" was nominated as “The best innovative project in the field of high-tech engineering and metallurgy" at St-Petersburg Engineering Fair and awarded the first degree diploma (the gold medal).