Ethiopian International Journal of Multidisciplinary Research

pISSN:2349-5707 Volume:13,Issue 4, April -2026 eISSN:2349-5715

PROCESS OF ANALYSIS OF THE MICROSTRUCTURE OF NON-FERROUS METALS AND ALLOYS ON AN INVERTER METALLOGRAPHIC MICROSCOPE OF THE OXION INVERSION OX.2653 PLMI BRAND

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Abstract

In this article, the microstructure of non-ferrous metals such as copper, aluminum and babbitt and their alloys was analyzed using an Oxion Inversio OX.2653 PLMi metallographic microscope. The physicochemical and structural properties of each metal and alloy — grain size, phase composition, modification effects — were evaluated based on microphotoanalysis.

The results obtained substantiate the possibilities of using these metals as structural and antifriction materials. The article is useful for specialists conducting research in the fields of materials science, mechanical engineering and metal analysis.

Keywords

non-ferrous metals, microstructure, copper alloys, aluminum alloys, babbit, microscope, microphoto, silumin, bronze, brass, antifriction, structural phase, phases, crystal, eutectic, modification, grain size, metallography, analysis, PLMi.

1. Introduction

Non-ferrous metals are widely used in mechanical engineering, electrical engineering, aviation and construction industries. Their microstructure determines the mechanical, thermal and corrosion properties. In particular, alloys based on copper, aluminum and babbitt are of practical importance due to their high electrical and thermal conductivity, low density, strength and richness in antifriction phases. In this article, the microstructure of these metals and alloys was studied using an inverter microscope.

2. Methods. For the study, samples of alloys based on copper, aluminum and babbit were prepared. Metallographic preparation (grinding, polishing, engraving) was performed on each sample. The analysis was carried out on an Oxion Inversion OX.2653 PLMi microscope at a magnification of 100x - 500x.

Brass and bronze for copper alloys, deformable and cast silumin alloys for aluminum, Sn-Sb-Cu, Pb-Sn-Sb-based compositions for babbit were examined. Based on microphoto and phase analysis, structural phases were determined - α, β, eutectic, eutectoid and solid solutions.

Copper-based alloys. The melting point of copper is 1083^0C, the boiling point is 23600C. The strength limit of pure copper is low, it is 220 MPa. The crystal lattice is face-centered cubic. The density of copper is 8.93 g/cm^3. Copper is characterized by high electrical conductivity, thermal conductivity and ductility, as well as corrosion resistance and the ability to form technological alloys that are well processed and have good mechanical properties. Two groups of copper-based alloys are used in technology: brass and bronze.

Brass. Alloys of copper with zinc and small amounts of other elements are called brass. Alloys consisting only of copper and zinc are called simple brasses, while alloys with aluminum, iron, lead, nickel and other elements are called complex or special brasses.

pISSN:2349-5707 Volume:13,Issue 4, April -2026 eISSN:2349-5715

According to their structural properties, brasses used in practice can be divided into two types:

1) single-phase α-brass with up to 39% Zn;

2) two-phase α + β-brass with a content of 39 to 45% Zn.

Single-phase α - brasses have the highest ductility, are well processed under pressure in both cold and hot conditions, and are resistant to corrosion. α-brass includes grades l 96, l90, l80, l68. Their structure consists of grains of α-solution.

Two-phase brasses have lower ductility and are well processed by pressure in the hot state if they are transferred to the single-phase ß state. Two-phase brasses include grades l62, ls59-1 (Fig. 1) and l59. At room temperature, their structure consists of light-colored grains of α-solution and dark-colored inclusions of the ß-phase.

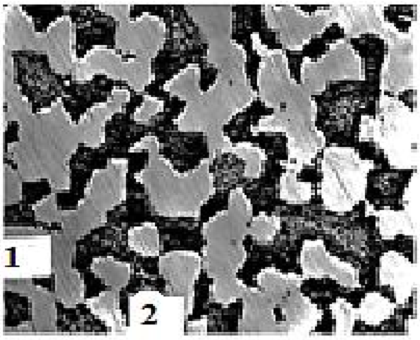


Figure 1. Microstructure of ls59-1 brass.

Legend: 1- light-colored grains of α-solution, 2- dark-colored inclusions of ß-phase

To improve mechanical, corrosion and other properties, alloying elements are added to brasses: silicon, manganese and aluminum, which do not form new phases, since they are in solution in the α and ß phases. Lead is added to two-phase brasses to improve machinability.

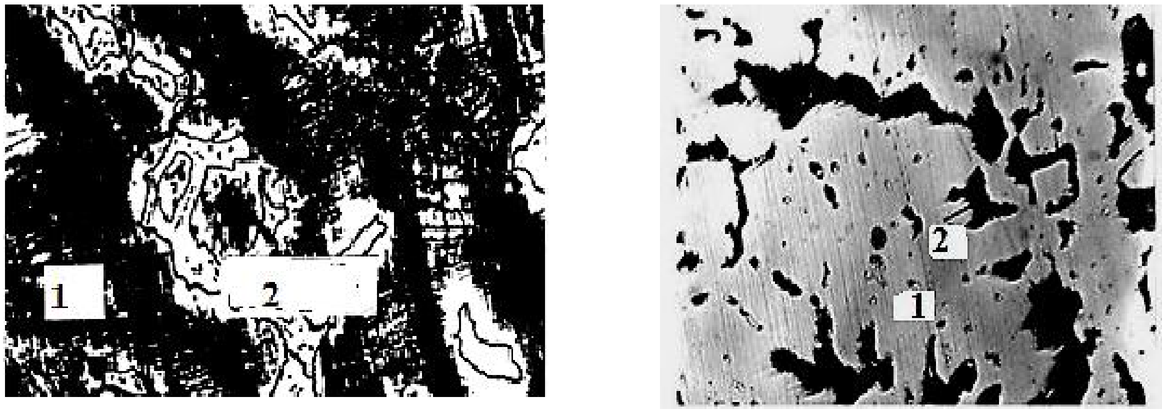
Single-phase α-brass containing up to 39% Zn does not undergo phase transformations, therefore they are not heat treated. Brasses are used for the production of pipes, tapes, foils, bushings, gears and fittings.

Bronze. Alloys of copper with tin, aluminum, manganese, silicon, beryllium and other elements are called bronzes (Fig. 2).

Tin bronzes are more durable and corrosion-resistant than copper, and have high casting properties. A low coefficient of friction and wear resistance make them suitable for the production of bearing parts, worm wheels and fittings operating in water or steam.

Zinc, phosphorus and nickel added to tin bronze improve its properties and increase the eutectoid content, but do not form new phases, since these elements are in solid solution. Lead, which is insoluble in copper and is included in tin bronze, improves the machinability of bronze. Bronzes containing up to 9.8% aluminum, when cooled slowly, form a uniform solid solution of aluminum in copper and a single-phase α-phase.

pISSN:2349-5707 Volume:13,Issue 4, April -2026 eISSN:2349-5715



a *b*

Figure 2. a. Microstructure of Бр010 brand bronze: 1-a-phase, 2-eutectoid+$Cu_{31}Sn_{8}$), b. Microstructure of БрС30brand lead bronze: 1-Cu, 2-Pb

Silicon bronzes have high mechanical properties and corrosion resistance.

Alloys containing 9.8-15.2% aluminum are two-phase alloys consisting of α-melting grains and α + δ eutectoid sections. Two-phase aluminum bronzes are quenched and tempered by heat treatment. The quenched alloy has a martensite-type structure consisting of needle-shaped crystals of the β phase. After quenching, the alloy structure consists of a fine mechanical mixture of phases.

Two-phase aluminum bronzes have greater toughness, but lower ductility than single-phase bronzes and are used to produce products with heavy loads.

Beryllium bronzes have high strength and elasticity, they are used to produce springs.

Aluminum-based alloys. The melting point of aluminum is 660^0C, the boiling point is about 2500^0C. The tensile strength is 90-180 MPa, it has high ductility, which allows it to be rolled into very thin layers. The crystal lattice is face-centered cubic, the density is 2.7 g/cm^3, which determines its wide application. Aluminum has good electrical conductivity, high thermal conductivity and heat capacity, and is chemically resistant to organic acids. It oxidizes very quickly in air, becoming covered with a thin oxide film, which prevents oxygen from entering the metal. Aluminum is difficult to cut and has a significant (1,8%) inclusion in the cast iron. To improve these properties, copper, magnesium, zinc, silicon and other elements are added to aluminum.

Aluminum-based technical alloys are divided into two groups: deformable and cast.

Deformable alloys include alloys in which a small amount of other phases of the solid solution or one solid solution is in equilibrium and has high plasticity. Al-Cu-based alloys constitute the largest group and are widely used in various fields. In this system, in turn, a distinction is made between wrought and cast alloys. Of the deformable alloys, alloys of the AK2, AK4, AK6, AK8 brands and alloys of the D1, D6, D16, D18 duralumin brands have high strength and fairly high plasticity.

Duralumin is a alloy that contains elements such as copper, magnesium, manganese and silicon, which form chemical compounds with aluminum and have variable solubility in aluminum. The heat treatment process of duralumin consists of heating, annealing, natural, and artificial aging. Rapid cooling in water allows you to obtain a supersaturated single-phase solid solution. In the annealed state, duralumin is soft, plastic and easily deformed. Alloys such as duralumin are widely used in industry, especially in aviation and rocketry.

Antifriction babbit alloys. Babbit is a low-melting alloy used for the manufacture of sliding bearing parts. Depending on the element that makes up the alloy base, tin, lead, aluminum and zinc babbits are distinguished. The high antifriction properties of these alloys are provided by their plastic base and structure consisting of hard additives.

pISSN:2349-5707 Volume:13,Issue 4, April -2026 eISSN:2349-5715

The highest quality is considered to be babbit B83, which contains 83% tin, 11% antimony and 6% copper. Due to the high concentration of tin, this babbit is the most expensive and is used for casting bearings for shafts operating at high rotational speeds.

Babbit B16 is a cheaper babbit, containing 16% antimony, 2% copper, 16% tin and 76% lead and is inferior in quality to babbit B83. In Babbit B16, the soft base is a solution of antimony and tin in lead, and the hard additives are chemical compounds SbSn and Cu_3Sn. Babbit grade B16 is used for casting bearings of tractors and automobile engines.

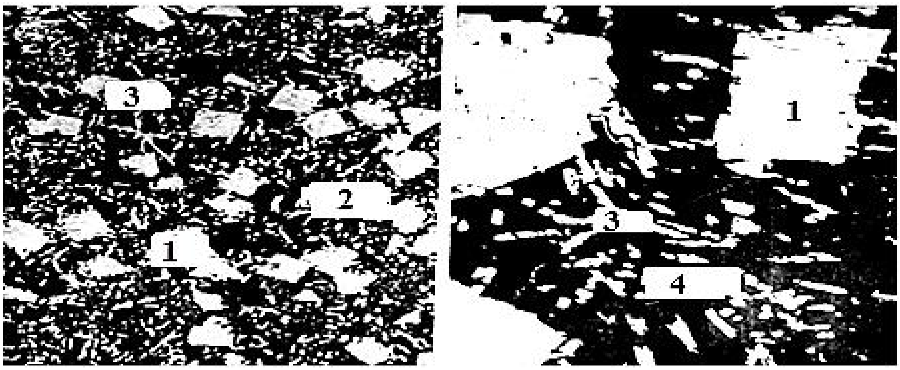
In babbit grade BS, the soft base is eutectic α+β, which is not plastic enough, and the hard crystals are ß–solution and the chemical compound Cu_2Sn. babbit grade BS has the worst properties compared to other babbits, but due to its low price, it can be used for shafts of mechanisms with low rotational speeds and engine bearings.

The microstructure of tin babbit B83 after rapid cooling (Fig. 5, a) consists of small solid cubes of the SnSb compound, a solid support of the Cu_6 Sn_5 compound and a viscous base of the ternary eutectic of solid solution of Sb and Cu in tin, as well as particles of Cu_6 Sn(5) and SnSb.

In the case of overheating and slow cooling of tin babbit B83, its structure becomes coarse, which sharply deteriorates its properties (Fig. 5, b); the solid particles of SnSb become very large, and the solid support of Cu_6Sn_5 also increases.

Testing procedure: The process of performing microstructural analysis of non-ferrous metals using an Oxion Inversion OX.2653 PLMi inverter metallographic microscope consists of the following steps.

Samples of copper-based alloys, aluminum-based alloys, and babbitt antifriction alloys are prepared. Microstructure analysis of samples of copper-based alloys, aluminum-based alloys, and babbitt antifriction alloys using an Oxion Inversion OX.2653 PLMi inverter metallographic microscope.



a *b*

Figure 3 Babbitt B83, x200. a- normal fine-grained structure,

b- coarse-grained structure after casting with overheating.

Legend: 1-SnSb; 2-terminal eutectic; 3-Cu_6Sn_5 ; 4-eutectic.

Conclusion: What are the properties of copper, aluminum and babbit-based alloys and their applications?

3. Results:

pISSN:2349-5707 Volume:13,Issue 4, April -2026 eISSN:2349-5715

• Copper alloys: In brasses, α and β phase grains were observed. In bronze, tin eutectic phases, sometimes beryllium martensites, are present.

• Aluminum alloys: In silumins, α + Si eutectic, acicular in the unmodified state, and fine-grained in the modified state, were determined.

• Babbit alloys: Small cubic crystals (Cu_3Sn, SbSn) were detected in the form of solid particles and are associated with antifriction properties.

Each analysis was evaluated based on a microscopic image (microphoto). It was observed that various modification methods significantly change the structures of silumin and babbit.

4. Discussion: The performance of metals and alloys is determined based on the microstructure. Copper alloys have high electrical and mechanical properties. Aluminum-based silumins are suitable for the casting industry, especially for automotive parts. Babbits are widely used in bearings due to their antifriction properties. Microscopic analysis shows that the structure can be significantly improved by modification.

The analysis results showed that high-quality structural grain size and stability of the necessary phases extend the service life of the product.

5. Conclusion: The microstructure of non-ferrous metals and alloys was successfully analyzed using the Oxion Inversion OX.2653 PLMi microscope. The structural properties of materials based on copper, aluminum and babbit proved that they are suitable for their practical applications. These properties can be significantly improved through modification and heat treatment.

In human history, non-ferrous metals such as copper, tin, and lead began to be used earlier than iron and its alloys, and their use dates back to the Bronze Age. The specific features of their atomic structure determine the properties of non-ferrous metals. It was found that many properties of elements have a clearly expressed periodic dependence on their atomic number.

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