M. M. Susan*, R. C. Baciu*, P. G. Dumitras**, Z. C. Predescu***

# CHANGES OF STRUCTURE AND PROPERTIES OF ALUMINUM ALLOYS SOLIDIFIED IN ULTRASONIC FIELD

*Asachi Tehnical University, Iasi, Romaina
59, Blv. D. Manjeron, Iasi, Romania
**Institute of Applied Physics, Academy of Sciences of Moldova
5, Academiei Str, MD 2028, Chisinau, Moldova
***"Politehnica" University, Bucharest, Romania

**Introduction**

The structure of the metal alloy (its phase composition, dimensions and shape of grains, distribution of the formed particles, etc.) constitutes an essential criterion that characterizes the quality of the obtained material.

The importance of structural parameters is determined by the fact that they directly influence physical and mechanical properties of the metal alloy.

An efficient way of improving the metal alloy structure is the use of ultrasound action during the solidification process. Ultrasound excitation of metals in the melted state may be achieved by direct acting of ultrasound on the bath with the melted metal, the mould, the casting form or other intermediate devices.

Using ultrasound during solidification of metal alloys yields materials with superior structural characteristics and improved properties [1].

**1. Experimental method**

Experiments were performed on the aluminum alloy ATC Si10Cu4 (3.6% Cu, 0.1% Mg, 11.2% Si, 0.5% Mn, 3% Zn, the rest – Al) and solidified in a mould under the action of ultrasonic field produced by a 1000 W ultrasound generator (USG) using the ultrasonic (oscillating) system shown in Fig. 1.

The useful power can be varied by modifying the intensity of the premagnetization current in the oscillating system, this condition may be achieved using the step cylindrical concentrators with various degree of amplification of the oscillation amplitude ($A$ = 8 – 25 μm).

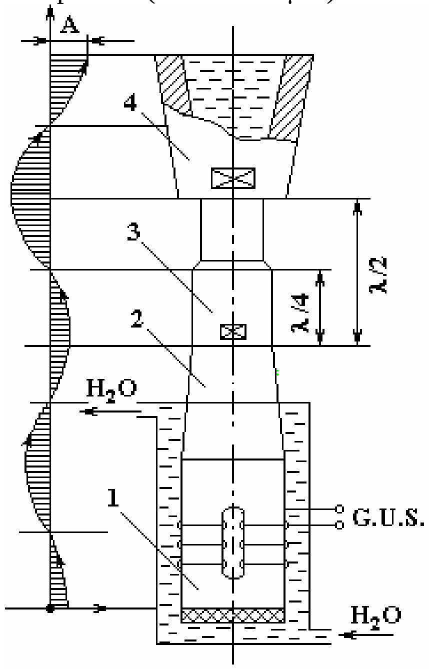


*Fig. 1. Scheme of the ultra sonic system. 1 – magnetostrictive transducer; 2 – standard concentrator; 3 – step cylindrical concentrator; 4 – micro-mould*

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The step cylindrical concentrators and the micromould are made of titanium alloys resistant to ultrasonic action [2].

**2. Experimental results**

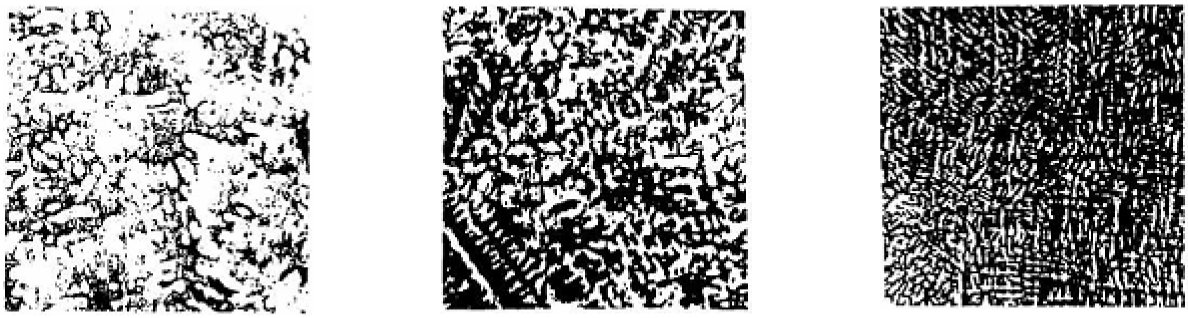
Samples of the ATC Si10Cu4 alloy were solidified in ultrasonic field with the frequency of $v$ = 17.5 kHz and $P_{us}$ = 100 – 350 W. In order to get the maximum efficiency of ultrasound the ultrasonic field was switched on till the end of the solidification process.

These samples were analyzed by diffractometry, their microstructure and hardness were also investigated.

The diffractometric analysis has shown the presence of Al, Cu and Si as distinct phases in the solid solution, as well as the presence of chemical compounds $CuAl_2$, $Cu_2O$ and $AI_2O_3$ (Table 1).

Microscopic investigations confirmed that the dendritic structure of the samples solidified in usual conditions ($P_{us}$ = 0 W) transforms into the cellular structure in the samples solidified in ultrasonic field, Fig. 2.

It should be noted that chemical compounds $CuAI_2$, $Cu_2O$ and $AI_2O_3$ can be found at grain boundaries of the solid solution.



a b c

*Fig. 2 Structure of the solid ATC Si10Cu4 alloy. a – normal solidification; b – solidification in ultrasonic field, A = 8 µm; c – solidification in ultrasonic field, A = 25 µm (chemical reagent – 0.5% HF; magnification 100 : 1)*

*Table1. Phases found in ATC Si10Cu4 alloy solidified in ultrasonic field*

| Sample | Ultrasound power, $P_{US}$ (W) | Phases | | | | | | Hardness, HB (N/mm$^2$) |
|---|---|---|---|---|---|---|---|---|
| | | Al | Cu | Si | $CuAl_2$ | $Cu_2O$ | $Al_2O_3$ | |
| 1 | 0 | (111) (200) | (111) (200) | (111) (220) | (110) | - | (101) | 691 |
| 2 | 100 | (111) (331) | (111) (222) | (400) - | - | - | (123) | 715 |
| 3 | 125 | (111) (200) | (111) - | (111) (220) | (110) - | (110) | - | 742 |
| 4 | 150 | (111) (200) | (111) (311) | (111) (220) | (110) | (110) | (101) (123) | 771 |
| 5 | 175 | (111) (200) | (111) (220) | (111) (220) | (110) | (110) | (101) (123) | 802 |
| 6 | 200 | (111) (200) | (111) - | (220) (400) | (110) | - | - | 831 |
| 7 | 225 | (111) (200) | (111) (220) | (111) (400) | (110) | - | - | 863 |
| 8 | 250 | (111) (200) | (111) (220) | (111) (220) | (110) | (110) | (123) (233) | 900 |
| 9 | 275 | (111) (200) | (111) - | (111) (220) | (110) (112) | (110) | (101) (123) | 942 |
| 10 | 300 | (111) (200) | (111) - | (111) (220) | (110) (112) | (110) | (123) | 981 |
| 11 | 350 | (111) (200) | (111) - | (111) (220) | (110) | - | (112) (101) | 1021 |

**Conclusions**

The experimental results may be explained on the basis of a decrease of the surface tension at the boundary surface between the metal melt and the micromould wall, as well as at the interface solid phase – liquid phase, due to the increase in the adhesion between the elements in contact.

Ultrasonic excitation of the micromould decreases the degree of undercooling and increases the nucleation ability of the melted metal, favors the formation of fine-grain microstructure with superior mechanical properties.

The increase of the oscillation amplitude and, hence, of the ultrasound power results in the decrease of the crystalline grain size, the elimination of some solidification defects and substantially increases the hardness of the studied alloy.

## REFERENCES

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2. Dragan, 0v., et al., Ultrasunete de mari energii., Ed. Academiei, Bucuresti, 1983.

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**Summary**

Ultrasonic field was applied to melted metal alloys during their solidification with the aim to obtain their microstructure in solid state characterized by small size grains. In the paper results of experimental research are presented obtained under application of an ultrasonic field of 100 - 350 W during the solidification of ATC Si10Cu4 alloy casted in a mould.