Metal-based nanocrystalline materials condensed from the vapor phase

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Introduction

Evaporation and subsequent condensation of materials in a vacuum is carried out with the help of an electron beam, which is characterized by the highest efficiency when processing metals in comparison with other known concentrated energy flows (laser, plasma). Electron-beam high-speed evaporation followed by condensation in a vacuum is used for the production of films for radio engineering, microelectronics, etc. Also this method is used for the production of Cu-Mo composite materials up to 5 mm thick.

The structure and phase composition of Co-Mo-based composites obtained on a steel substrate at 700°C (0-47 wt.% of Mo) have been studied in detail, but there is still almost no information on the complex influence of the main technological parameters on the physical and mechanical properties of such materials.

This presentation provides a stud of the mechanical characteristics of composites obtained by this method, in depending on the following parameters: material of the substrate, surface roughness, material and thickness of the separation layer, temperature of the substrate, depth and dynamics of changes in the vacuum of the chemical composition and rate of evaporation of the starting materials.

Experiments

Experimental samples of condensed composite materials were formed by evaporation-condensation of the initial components from two independent sources on a stationary substrate (with varying of Cu and Mo concentration along the length), as well as on rotating substrates (with alternating layers of Cu and Mo).

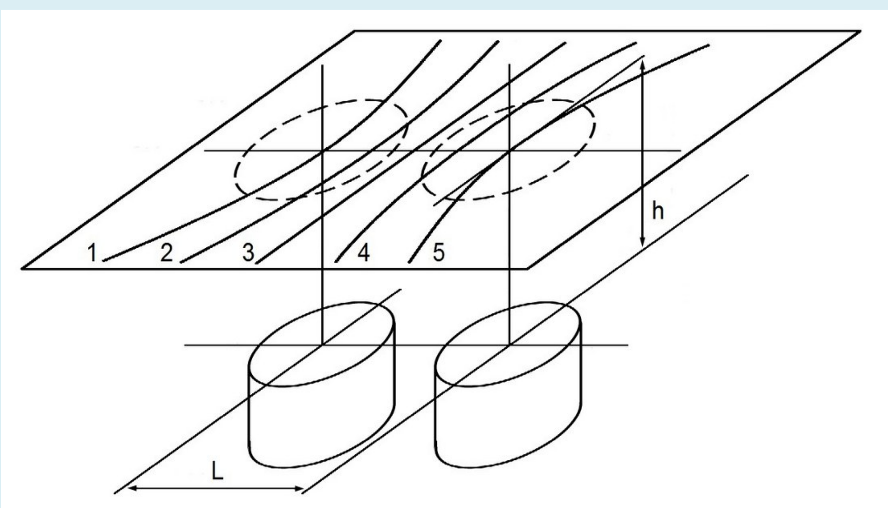


Fig.1. The scheme of obtaining condensed composite materials on a stationary substrate (1, 2, 3, 4, 5 – lines of constant concentrations).

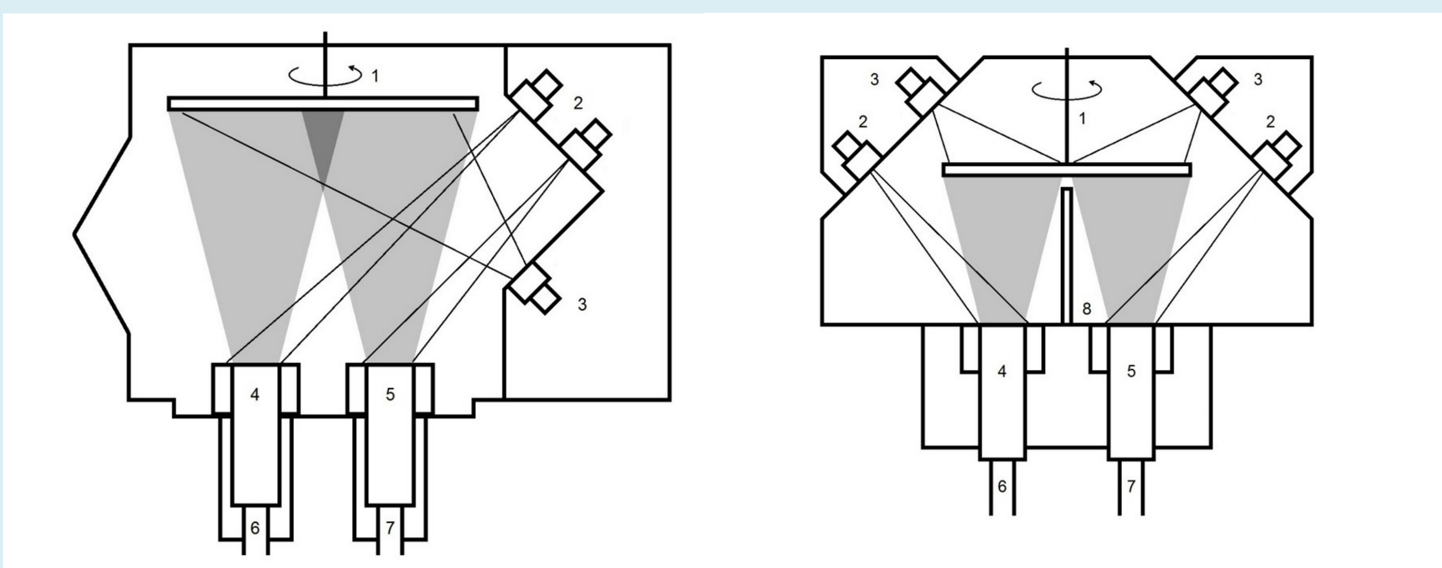
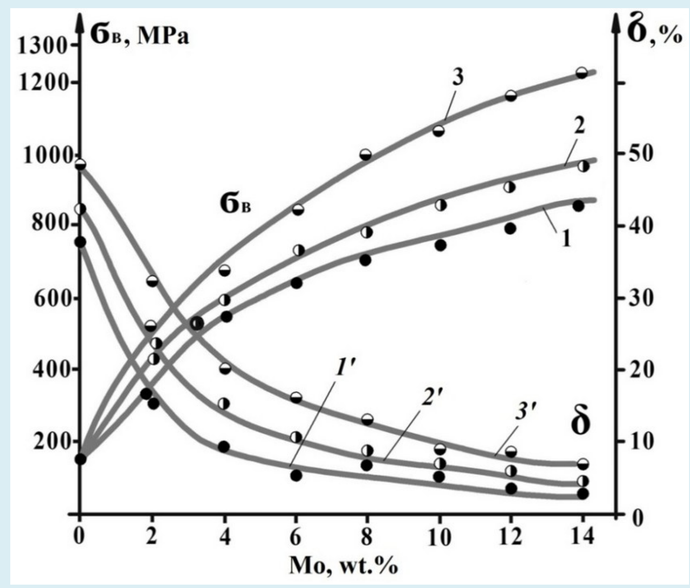


Fig.2. The scheme of obtaining composite Cu-Mo materials on a rotating substrate with a constant (a) and adjustable speed (b).

On the scheme: 1 – rotation mechanism of the substrate, 2 – 100 kW heaters for evaporation of initial materials, 3 – 20 kW heaters for heat the substrate, 4, 5 – evaporation units, 6, 7 – mechanisms for feeding materials, 8 – copper water cooling screen for separation of steam flows of copper and molybdenum.

Results and discussion

As a result of studies of the strength limit and relative elongation of condensed microlayer materials (Cu-Zr-Y)-Mo, depending on the level of roughness of the substrate, it was established that the strength and plasticity of materials depend on the quality of the surface treatment.



1, 1' – milling by mill thin, stiffness coefficient 6-8, R_a = 1,6-0,63

2, 2' – fine grinding, stiffness coefficient 8-10, R_a = 0,63-0,16

3, 3' – electrochemical polishing, stiffness coefficient 12-14, R_a = 0,04-0,01

Fig. 3. Dependences of the strength limit σ_v (curves 1-3) and the relative elongation δ (curves 1'-3') of condensed composite Cu-Mo materials on the level of roughness of the substrate, on which was the condensation of the steam flow.

It was also found that the composites obtained at 900°C (R_a = 0.63) are 1.5 times inferior in mechanical properties to the materials obtained at 700°C which is explained by the formation of coarser-grained material structure at higher condensation temperatures

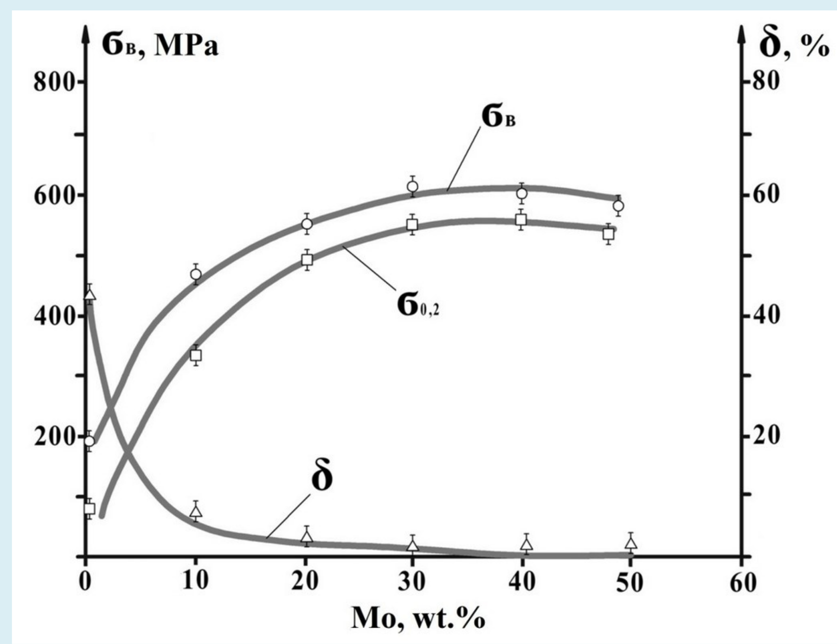


Fig. 4. Dependences of the tensile strength σ_v, yield strength $\sigma_{0.2}$ and relative elongation δ of materials obtained at 900 ±30°C from the amount of molybdenum

Conclusions

1. In materials with more than 14 wt.% of Mo obtained at 700°C, strength is a dramatic decrease due to the formation of pores, but increasing the temperature of the substrate to 900°C allowed obtaining composite Cu-Mo materials with a refractory phase up to 45 wt.%.
2. Decrease of the roughness of the substrates leads to an increase in the ultimate tensile strength and elongation.
3. Structural defects in the form of rods formed on micro-droplets ejected from the evaporator are the cause of reduced strength and ductility of condensed composite materials.

References

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