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ON SOME DEVELOPMENTS OF TECHNOLOGY OF MULTIFILAMENTARY WIRE V_3Ga

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The last twenty years have brought along a big evolution in the field of the application of the superconducting materials. It is a valuable task to improve the superconducting critical parameters, T_c, H_c and I_c. As the experiments show some improvement can be achieved by adding other alloying elements to the superconductors in a low concentration. Taking into account of the advantageous properties of Al there are some experiments and considerations to make superconducting wire in Al matrix.

Introduction

The critical temperature T_c and the critical magnetic field H_{c2} depend on the microscopic physical properties of the basic material as it can be seen in Table I. However the critical current I_c is determined mainly by the technology, by the inhomogenities, the dislocations and the other crystal imperfections [1-2].

In mixed state of a superconductor the so-called pinning centres prevent the Lorentz motion of the flux line. The critical current density j_c is related to the mean pinning force $\underline{F}_p$ (B) by the critical state equation

$$\underline{j_c} \times B + \underline{F}_p (B) = 0 ,$$

where $\underline{B}$ is the magnetic field. $\underline{F}p$ is determined by the interactions between the flux line and the crystal imperfections.

Recently some manufacturing technologies exist for BCC superconductors, first of all for Nb-Ti, Nb-Zr, because their critical parameters are not too sensitive for composition. This solid solution superconducting phase can be worked well mechanically too.

However from the point of view of the high critical parameters the compound of A15 structure is favourable. Among the A15 superconductors the Nb-Sn and the V-Ga systems have stable A15 phases in a wide range around the stoichiometric composition.

For multifilamentary superconductors V_3Ga there are two technologies: 1. Surface diffusion process (SDP); 2. Composite diffusion process (C DP) By some reasonable modifications we can get higher values in the critical parameters extremely in the critical currents.

Some improvements in the critical parameters

In A15 superconductors the dominant pinning centres are the grain-boundaries [4]. When the grains are less we can get stronger pinning forces and the critical current is higher. The grain size can be limited by the temperature of heat treatment. However, at the heat treatment the thickness of the superconducting layer also decreases with the decreasing of the temperature.

Adding different alloying elements to the matrix or to the pure materials the diffusion constant can be increased due to the decrease of the activation energy [5-6] .

In the Fig. 1 the critical currents are plotted against the annealing time in some superconducting samples.

As it can be seen the critical currents increase with the annealing time. We mentioned that the changing of the critical current with the reaction time is influenced by two effects mainly. One of them is the growth of the superconducting layer and the other is the formation of the grain size. The critical current increases approximately monotonically with the thickness of the superconducting layer and so with the reaction time, but when the grain size will be larger j_c will decrease and so the strength of the pinning force.

From the results we can establish that the effect of the alloying of In is the highest . It surpasses the effects of Al and Zn. The element In owes the best effect to the largest superconducting layer due to the best diffusion of Ga. But after annealing of one hundred hours the grain size becomes too large and the critical current density will be lower.

In the Fig. 2 the critical temperature T_c is plotted against the annealing time in the same samples.

As we can see the solution of the additional elements in V_3Ga layer is a limited process because the critical temperatures change hardly.

Taking into account the advantages of element Al a new idea arises for the further modification of the V_3Ga technology. The element Al is very promising as a matrix material in the multifilamentary superconductive wires because its mass density is only one third of that of Cu, the electric and thermal conductivity is approximately that of Cu at low temperatures but it is much cheaper.

The first task in the CDP technique is to examine the Al-Ga system from the mechanical and electric points of view. In previous works we can find two different phase diagrams for Al-Ga. One of them is a simple eutectic system with limited solid solubility. The other one has three intermetallic compound phases.

In our early experiments the Al-Ga samples were produced by melting of the pure metals in a quartz tube under argon atmosphere. The compositions were next to the assumed intermetallic compounds. The content Ga prevented the development of the Al oxide layer and the samples were damaged in a relatively short time. The samples were porous, brittle and plastically undeformable. The unsuitable properties of the Al-Ga alloys demand the further modifications of CDP technique or other SDP techniques.

References

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Table I

Critical parameters of superconductive materials of different crystal type

Crystal Type	Material	T_c(K)	H_{c2}(4,2K)(T)
BCC	Nb-Ti	9.8-10.2	12
	Nb-Zr	10.8	11
A15	Nb_3Ga	20.7	34.1
	Nb_3Al	18.6	25.2
	Nb_3Sn	18	23.5
	V_3Ga	15.9	22
	V_3Si	17	22.8
C15(Laves)	HfV_2	9.2	20
	ZrV_2	8.5	
	$Hf_{0.5}Zr_{0.5}V_2$	10.1	23
TMS(Chevrel)	$SnMo_6S_8$	11.7	
	$PbMo_6S_8$	14	

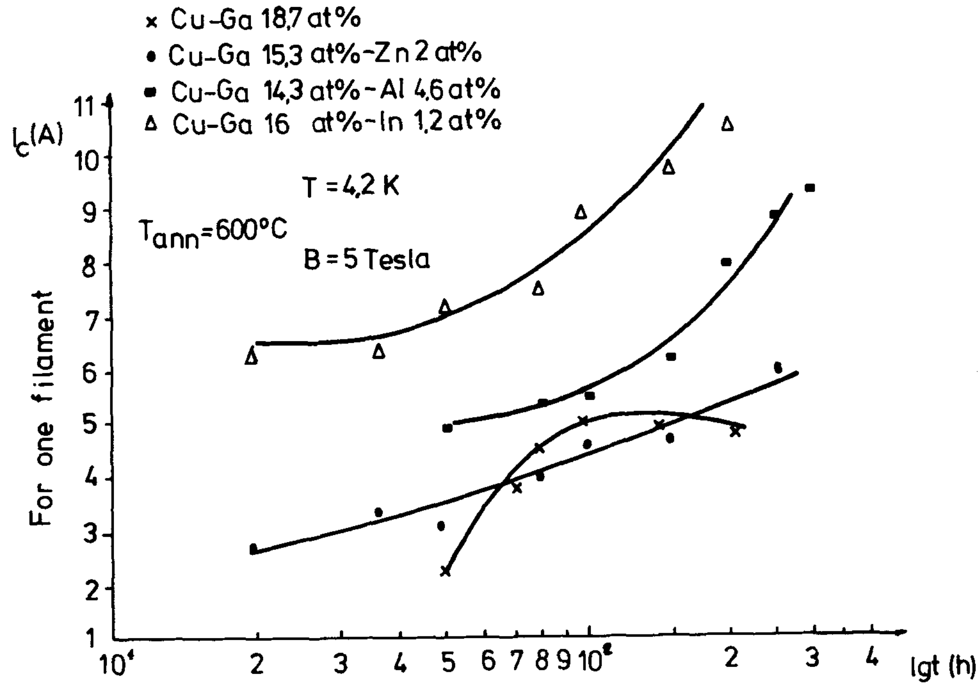

Fig.1. Critical current vs. reaction time of conductors with different compositions of the bronze

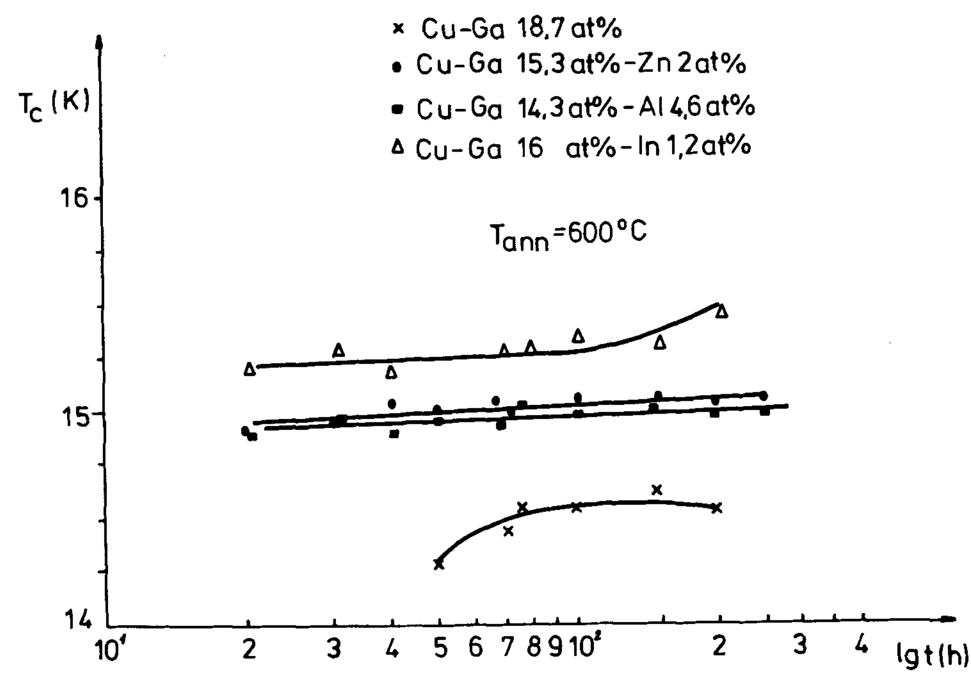

Fig.2. Critical temperature vs. reaction time of conductors with different compositions of the bronze