

Transformation kinetics of A-15 superconductors formed by solid state reactions

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Abstract. Various fabrication processes devised for making multifilamentary A-15 superconductors are all based on solid state reactions, transforming the host metal into the binary A-15 phase. The kinetics of the growth process involved in the compound formation form the theme of this paper.

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1. Introduction

Phase transformation of bcc Nb into Nb₃Sn of A-15 crystal structure caused by solid state diffusion of Sn into Nb has led to several processing routes for fabricating Nb₃Sn in multifilamentary form. They include the conventional bronze process, in-situ and powder metallurgy techniques, the modified jelly roll process, etc. Actually, these processes are really no more than different ways of realizing composite conductors containing a large number of fine Nb filaments in a bronze matrix. Diffusion reactions at 550 to 800°C result in Nb₃Sn layers at the bronze-Nb interfaces (figure 1). V₃Ga and V₃Si are two other important binary A-15s of A₃B type produced in this way.

In any phase transformation one is confronted with two pertinent questions: (a) why does a particular phase change occur?, and (b) how does it occur? The answer to (a) requires thermodynamic considerations while that to (b) involves the kinetics. The thermodynamics of A-15 formation, described elsewhere (Dew-Hughes and Luhman 1978; Narlikar and Dew-Hughes 1985a, b) is considered outside the scope of the present paper.

Turning to kinetics, there are four types of kinetics associated with A-15 layer formation: (i) nucleation, (ii) grain growth, (iii) layer growth and (iv) ordering. Nucleation kinetics are of prime importance for compound formation. The critical current density J_c of the A-15 layer is controlled by grain growth kinetics. The overall critical current I_c is determined by layer growth kinetics. Finally, the critical temperature T_c depends sensitively on the long range order (LRO) of the compound layers, which in turn is determined by ordering kinetics. Interestingly, all the four processes come into operation almost simultaneously with the start of diffusion annealing.

In this paper we briefly describe the four kinds of kinetics. Although the kinetics story is basically independent of various fabrication routes referred above a greater emphasis is laid on the results obtained with bronze process. This is because its