Supercond. Sci. Technol. 10 (1997) 686–692. Printed in the UK

PII: S0953-2048(97)82152-5

Thermomechanical processing and reaction kinetics of Bi-2223 powder-in-tube tapes made from aerosol precursor

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Received 25 February 1997, in final form 7 May 1997

Abstract. Currently, powder-in-tube Bi-2223 superconductor is the most promising candidate for fabricating long-length conductors. Intensive investigations have shown that the critical current density of fully processed tapes is affected by a large variety of processing parameters. Among these are the thermomechanical processing schedule and the extent of Bi-2223 phase conversion. In this study, a powder precursor was prepared using an aerosol pyrolysis technique, which has been shown to have the advantage of reduced processing time. Powder-in-tube conductors were fabricated using the aerosol precursor powder, and the thermomechanical processing steps were varied. Different schedules were correlated with the amount of Bi-2223 phase as well as the critical current density. The number of pressings and the length of sintering time between pressings were found to be closely related to the critical current density at various stages of the thermomechanical treatment.

1. Introduction

For large-scale applications such as transmission cables, high-field magnets, motors and generators, long lengths of flexible conductors are necessary. Currently, the only high-temperature superconductor (HTS) that has been proven to be fabricated in long lengths using industrial processes is the powder-in-tube (PIT) $(Bi,Pb)_2Sr_2Ca_2Cu_3O_{10}$ (Bi-2223) tape. Short PIT samples have been shown to possess critical current densities (J_c) as high as a few tens of kA cm^{-2} at 77 K and self-field. These values of critical current density have been found to depend on a large number of processing parameters which were optimized by various investigations [1–4]. Among these are the precursor powder composition [5], initial tape deformation conditions [6] and core density [7, 8], thermomechanical processing parameters [9–11] and sample cooling rate [12, 13]. In particular, the thermomechanical processing parameters have been shown to affect strongly the extent of Bi-2223 conversion and the degree of grain alignment as well as the final HTS core density of the conductor. Since the formation kinetics of the 110 K Bi-2223 phase depends on variables such as precursor phase assemblage, homogeneity and particle size, Bi-2223 precursor powders produced by different techniques will require different thermomechanical processing schedules to achieve optimum J_c.

Precursor powder produced by the aerosol pyrolysis technique has been shown to be homogeneous and to possess fine particle size [14, 15]. Consequently, Bi-2223 phase conversion can be essentially completed in less than 100 h, while precursor powders manufactured by the majority of other methods typically require hundreds of hours for Bi-2223 conversion. In this study, PIT Bi-2223 conductors were fabricated using aerosol precursor powder, and an attempt has been made to understand the interrelationship between thermomechanical treatment and Bi-2223 conversion of aerosol precursor. This includes both the determination of Bi-2223 phase content as a function of thermomechanical treatment and the optimization of the thermomechanical treatment with respect to the number and duration of sintering intervals for high J_c.

2. Experimental details

2.1. Precursor and conductor processing

The Bi-2223 precursor powder used in this study was prepared by the aerosol pyrolysis technique. Details of