FLUX PINNING IN RHQT-PROCESSED Nb_3Al AFTER VARIOUS TRANSFORMATION HEAT TREATMENTS

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Introduction

The best properties of Nb_3Al processed by Rapid Heating-Quenching and Transformation are obtained by using two relatively new transformation heat treatments (THT): the Transformation-heat-based Up-Quenching (TRUQ) [1] and Double Rapid Heating/Quenching (DRHQ) [2]. Both start with an excursion to higher temperatures, ~1000°C and >1500°C, respectively. It has been found that the faster the initial heating to 1000°C, the higher the superconducting transition temperature, the upper critical field and the critical current densities (J_c) at high magnetic fields become. The J_c at low and intermediate fields cannot be easily determined by transport measurements because of stability problems. In addition, there is a degree of uncertainty regarding the critical fields determined from Kramer plots, so it was deemed more reliable to use magnetic measurements in fields up to 30T to determine the irreversibility field and the J_c.

Experimental

Sample transformed using four types of heat treatments (THT1 to THT4) [3] were prepared having the initial heating rates increasing from 1000ºC/30min (THT1) 1000ºC/30s. Two (to maximize VSM signal) 5 mm long pieces were cut from the center of each sample for magnetization measurements. The measurements were performed by vibrating sample magnetometry (VSM) in magnetic fields up to 30T. As the magnetic field was ramped from 0 to 30 T (or lower depending on sample and temperature) and down to 0 at 10 T/min the measured values of the magnetic moment were recorded along with those of the magnetic field. Measurements were performed at 4.4, 5, 6, 7 and 8K.

Results and Discussion

From the hysteresis loops (M-H) so obtained the dependence of the width of the loop on the magnetic field was calculated, which was then normalized to the volume of the superconducting filaments (including their Nb cores) in the sample to obtain the width of the magnetization loop ΔM. The critical current density was calculated from ΔM values according to [4]. The J_c values determined from the magnetic measurements at this temperature are presented in Fig. 1. The overall trend is for the J_c to increase as we move to THT-s with higher initial heating rate of the THT.
However, a lack of reproducibility has been put into evidence between samples prepared apparently under the same conditions, which is probably caused by slight differences in the RHQ heat treatment.
The irresversibility and upper critical fields have also found to increase as the initial heating rate of the THT is increased, but the data was more consistent for samples undergoing same THT.
Normalized pinning force curves calculated based on the Jc data show that pinning is not scaling with respect to temperature or THT. However the curves are fairly close to each other.

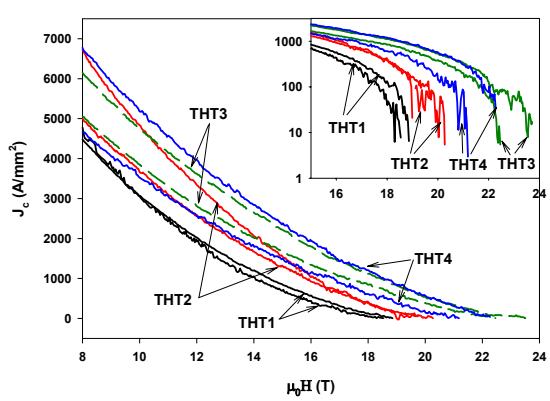

Fig. 1. Critical current densities at 4.4K for Nb_3Al samples transformed to A15 by different THT-s. Two samples have been measured for each THT.

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References

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