Changes in the Critical Properties of High-Jc NbTiTa Alloys with Final Drawing Strain

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Introduction

In NbTi alloys, $H_{c2} = 3.1\ \rho_n\ \gamma\ T_c$ and H_{c2} is determined by the composition of the β-phase matrix until the α–Ti ribbons become so thin after large strain that they form an SS'S proximity coupled single system again. Under these assumptions, T_c should increase, while H_{c2} is expected to go down after precipitation heat treatment (HT) because the matrix becomes more Nb-rich, while T_c should go up. However, results have revealed an increase in H_{c2} with drawing strain. The purpose of this study is to determine if cold work changes the resistivity, and hence H_{c2} of the non-HT condition.

Experimental

Vibrating Sample Magnetometer (VSM) measurements were made in order to examine the reversible magnetization discontinuity that defines H_{c2} of the NbTiTa alloys. Measurements were made over a temperature range of 2.5K to 10K and applied fields ranging from -2T to 14T. SQUID magnetometer (16T PPMS) and Specific heat (Cp) measurements were made in order to examine the effects of HT and drawing strain on the critical temperature (T_c) of the NbTiTa alloys. Measurements were made over a temperature range of 2.5K to 10K and fields of 0T and 16T (PPMS) and 50Oe (SQUID).

Results and Discussion

Figure 1 shows the expected behavior of T_c, H_{c2}, and ρ as the NbTi wires are drawn and α-Ti precipitates out of the matrix. Table 1 reveals the expected decrease in H_{c2} and increase in T_c with HT (UW310 series). However, evidence of cold work appears in the before-HT single β state, as H_{c2} (4.2K) unexpectedly rises with increased strain while T_c shows no significant trend. Thus it is likely that the increase in H_{c2} is associated with an increase in the resistivity. After the final heat treatment, both T_c and H_{c2} appear to be strain-dependent, as they both decline systematically over the measured range of ε_f = 2.6-5.6. T_c almost reaches the single phase value of 8.1K at ε_f = 5, but H_{c2}, although in sharp decline, is still well above its single phase value (10.87 vs. 11.75T) at about ε_f = 5.

Table 1: T_c and H_{c2} results of the CB9838 and 5304 NbTiTa alloys.

Sample	Strain	HT stage - diameter (in)	Hc2 (4.2K), T		T_c,(K) at 50% (SQUID)	
			BHT	AHT	BHT	AHT
5304 Rod	6.36	No HT- 0.281	10.87		8.1	
	6.42	No HT- 0.273	12.8		8.64	
	6.53	No HT- 0.2576	12.26		8.49	
	6.76	No HT- 0.2294	12.4		8.55	
	7	No HT- 0.204	12.54		8.62	
	7.46	No HT- 0.162	12.63		8.63	
	8.85	No HT- 0.0808	12.75		8.58	
	10.25	No HT- 0.040	12.78		8.59	
UW310	7	HT 1- 0.204		12.4		8.62
	8.39	HT 2- 0.102	12.65	11.7	8.63	8.94
	9.78	HT 3 - 0.05		11.6		9.2
		After final HT				
CB9838	2.61	0.035		12.3		9.1
	3.2	0.026		12.2		9
	3.49	0.0225		12.1		8.95
	3.95	0.0179		12.05		8.8
	4.41	0.0142		12		8.65
	4.86	0.0113		11.9		8.5
	5.34	0.0089		11.8		8.35
	5.56	0.0079		11.75		8.25
	5.77	0.0071		11.75		8.2

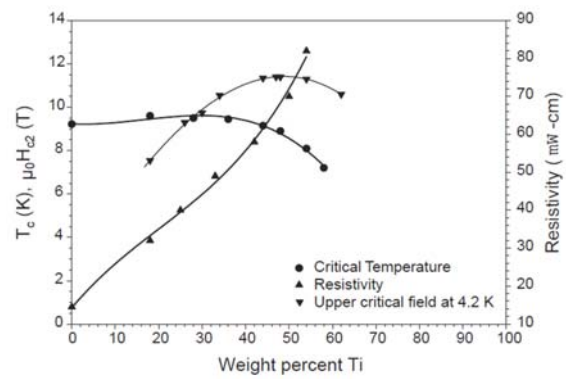

Figure 1: Shows the compositional dependence of T_c, H_{c2} and ρ_n

Conclusions

The H_{c2} of the non-HT wires appear to be affected by cold work, which likely drives up the resistivity of the wires. The H_{c2} of the HT wires was found to be dependent on wire diameter (and drawing strain).

Acknowledgements

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References

[1] P. Lee, *et al*., IEEE Trans. Appl. Supercon. 3, 1354 (1993)