ALUMINA PARTICLE-REINFORCED Nb_3Sn WIRE

J. Chen (FSU, Mechanical Engineering); K. Han, P.N. Kalu, W.D. Markiewicz (NHMFL)

Introduction

Conventional high-strength Nb_3Sn superconducting wires have low volume fraction of Cu stabilizer or none-copper component because they enclose a certain amount of high strength material as a strengthening component. Consequently, increase of strength is accompanied by reducing the critical current or stability. This report describes a new type of Nb_3Sn wire, in which a small amount of dispersed Alumina nano-particles were added into both Nb_3Sn and CuSn matrix. By this way, the volume fraction of Nb_3Sn wires and Cu stabilizer remains almost the same as the conventional wires, but both the strength and critical current are enhanced.

Results and Discussion

A cross-sectional image of one of the fabricated wires is shown in Fig.1. DSC represents dispersion strengthened copper, that transform into dispersion strengthened copper-tin during the reaction.

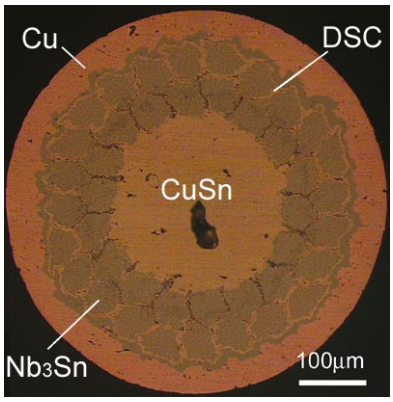

Fig.1 Cross section of developed DSC reinforced Nb_3Sn wire.

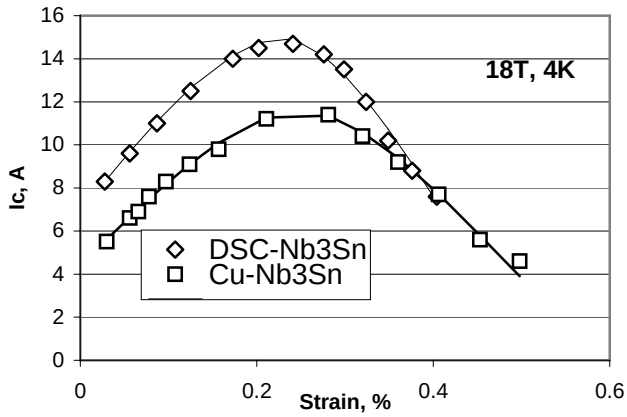

Fig.2 Ic vs. Strain relation of strengthened and regular wires.

Critical current was measured with uniaxial tensile load, at 4 K and magnetic field of 18T. The results are shown in Fig. 2. The solid lines in the figure are the fitting curves based on Summers's formula. The maximum Non-Copper J_c at 18 T and 4 K is 87 A/mm^2 and 67 A/mm^2 for DSC-Nb_3Sn and Cu-Nb_3Sn respectively. Therefore, additions of nanoscaled Al_2O_3 particles enhance the critical current by 28%. ε_m (the strain, where maximum I_c is reached) of Cu-Nb_3Sn is very close to the one of DSC-Nb_3Sn. This is because the conductors were soldered on stainless steel backing plate before testing, so the prestrain after cooling was mainly influenced by the backing plate. The stress-strain curves of DSC-Nb_3Sn and Cu- Nb_3Sn wires are compared in Fig.3. The 0.2% yield stresses of DSC-Nb_3Sn and Cu-Nb_3Sn wires are 220MPa and 200MPa respectively. This corresponds to a 10 % increase of strength.

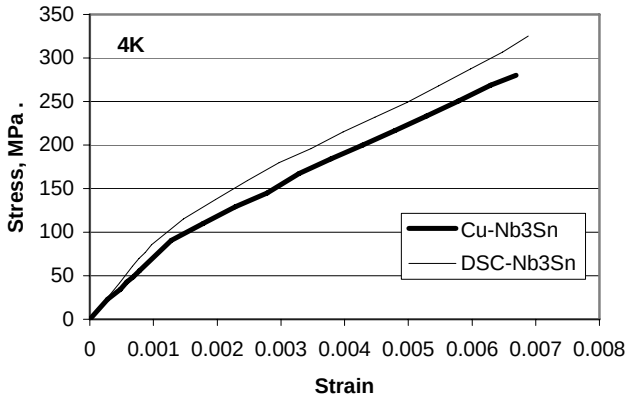

Fig.3 Stress-strain curves at 4K for DSC-Nb_3Sn and Cu-Nb_3Sn wires.

Conclusions

Al_2O_3 particles reinforced Nb_3Sn wires were fabricated. The reinforced wires show both the higher mechanical strength and J_c at 18T than conventional wires. The unique characteristic in this technology is that the volume fractions of each component in Nb_3Sn wire remain the same, therefore, any improvement in strength or in superconducting properties results in no loss of others.