High Strength, high conductivity Cu-(Ta-W) composite wires

Balachandran, S., Lee, P.J., Larbalestier, D.C., Cooley, L.D., Starch, W.L., Walsh, R.P. (NHMFL), Smathers, D.B. (HC Starck)

Introduction

Pulse magnets require conductors with strengths greater than 550 MPa, high modulus (>120GPa), and high conductivity. Strength enhancements in Cu can be through the dispersion of oxides in the Cu, an example being Glidcop® (Cu-Al_2O3), or by the introduction of ductile strengthening elements as in Nb/Ta[1-3]. Here we demonstrate that a Ta-W alloy (NRC76®) in a Cu composite can provide a new pathway to obtain strengths over 650 MPa, while maintain a conductivity of about 80%IACS.

Experimental

Composite Cu-TaW conductors were fabricated at Applied Superconductivity Center (ASC, NHMFL) using Ta-W alloy supplied by HC Starck. The mechanical testing was performed using the facilities at NHMFL.

Results and Discussion

We were able to fabricate a multifilamentary composite using standard wire drawing techniques using high modulus (200 GPa), high strength (>900 MPa) Ta-W alloy rods in a Cu101(high purity Cu) matrix as shown in Figure 1. The new composite fabricated at NHMFL has a higher modulus (140 GPa) than the other conductors that are presently being employed for pulse magnet applications (Table I). The combination of high strength (665 MPa), and conductivity (80% IACS) conductivity, as shown in Table I, provides a unique opportunity to manufacture cross-sections as large as 30 mm^2 for future pulse magnet conductors targeting magnets beyond 100 T. The fabrication procedure used to manufacture these re-stack conductors is commonly used for other superconducting magnet technologies and thus we believe should scale readily to full size composites.

Conclusions

These new Cu/Ta-W micro-composites offer the possibility of reaching >100 T targets at a reasonable cost in raw materials and development time. The design of these new Cu/Ta-W micro-composites is straight forward, and offers better design control to tailor strength and conductivity. Cu-Ta-W can be drawn to large strains, and long lengths of wires are possible. Cu-Ta-W also has potential to be developed into a conductor with finer Ta-W filament spacing in a Cu matrix, making it possible to reach even higher strengths.

Acknowledgements

The National High Magnetic Field Laboratory is supported by the National Science Foundation through NSF/DMR-1157490/1644779 and the State of Florida.

References

[1] K. Han, *et al.*, IEEE TAS, **28**, 3 1-5 (2008).
[2] K. Han, *et al.*, Mater. Sci. Eng. A, **267**, 1 99-114 (1999).
[3] N. I. Kozlenkova, *et.al.*, IEEE Trans. Magn, **32,** 4 2921-2924 (1996)

Table I Summary of Tensile test and resistivity measurements

	Mechanical Behavior (Test temperature 295K)					Electrical Property	
Specimen	Modulus, E (GPa).	Yield (0.2%) (MPa)	Tensile strength, UTS (MPa)	Resistivity, ρ (Ωm)		%IACS+	RRR=$\frac{\rho_{295K}}{\rho_{77K}}$
				295K	77K	295K	
Ta-W	204	945	965	-	-		-
Cu-Ta-W	143	645	665	2.17E-8	2.99E-9	79.5 ± 0.8	7.24
GlidCop[1] AL60	111	524	565	9.55E-8	2.22E-8	82 ± 1	4.3
Cu-Ag[2]	115	800-900	850-950	2.39E-8	7.6E-9	76	3.1
Cu-Nb[2,3]	110-125	700-1200	500-1600	-		85-55	4.4

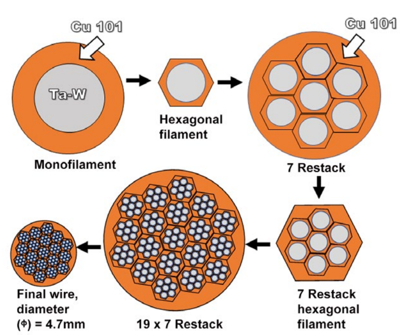

Fig.1 Schematic of fabrication of Cu-Ta-W multi-filamentary restack conductor. The initial Cu-Ta-W monofilament underwent two separate restack steps to form a 19x7 restack conductor with a final wire diameter of 4.7 mm