S4-O-038401

DEVELOPMENT OF MATERIAL BASED ON NANOSTRUCTURED Cu-Nb ALLOY FOR HIGH MAGNETIC FIELD COILS*

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The nanostructured Cu-Nb composite, characterized by high conductivity and tensile strength, is a candidate material for the development of tool coils (inductors) for magnetic pulse processing technologies exploiting high, 30–50 T, magnetic fields (HMF) of 10–100 µs in duration. Using it in the form of a wire, reliable 70 T multi-turn pulsed magnets of subsecond pulse duration are being developed [1], but it was not studied under the generation of microsecond HMFs due to the availability as a wire only. The aim of this work is to produce a material based on Cu-Nb alloy by powder approach, to study the effect of TiC addition on electrical, mechanical, structural properties and the behavior of the materials, including layered structures on their basis [2], under the generation of 40 T magnetic field as compared to commercial wire.

Cu-18% Nb commercial wire 0.15–0.18 mm in dia obtained by “melting and drawing” technique [3] (50% IACS, 1.57 GPa UTS, Nanoelectro LLC Company) was used as a raw material to obtain a powder with particles 20–64 µm in size by ball milling the wire in petrol. To form the layered structures with layers that differed in resistivity TiC was added to the base Cu-Nb powder (BP) in amount 10–20 vol.% through a ball milling. As-milled powders after vacuum annealing at 500°C were then pressed by magnetic pulsed compaction (MPC) in evacuated and preheated to 430°C mold at a pressure pulse of 1–1.3 GPa. Annealing in vacuum for 1 h at temperatures up to 850°C was performed to study its effect on materials density, conductivity, structural characteristics, and mechanical properties.

For testing the materials in HMFs, some samples of 32 mm in dia, including the sample with bi-layer structure (Fig. 1a), were cut into bars having a cross-section 2×8 mm close to that of commercial Cu-18%Nb multicore rectangular wire of the same manufacturer. It was done to compare the commercial and lab materials in close conditions. The bars cut of the pellets and commercial wire were the brazed parts of a duplex field shaper (DFS, Fig. 1b) which was placed inside a capacitor-driven single-turn inductor. The testing conditions were: peak magnetic field – 40 T, half-period – 15 µs, discharged peak current – 540 kA.

The results. Generally, the powder samples were more hardened and thermally stable then initial wire. Addition of TiC particles resulted in increasing both the composite microhardness and resistivity, and the lowering the tensile strength at the same time. As expected, the powder samples were inferior in some performance to commercial wire. However, such an approach is considered to be acceptable for producing the massive articles of complex shape like field shapers. Under the generation of 40 T magnetic field, the powder samples exhibited a comparable to commercial wire lifetime, about 100 pulses (Fig. 1c).

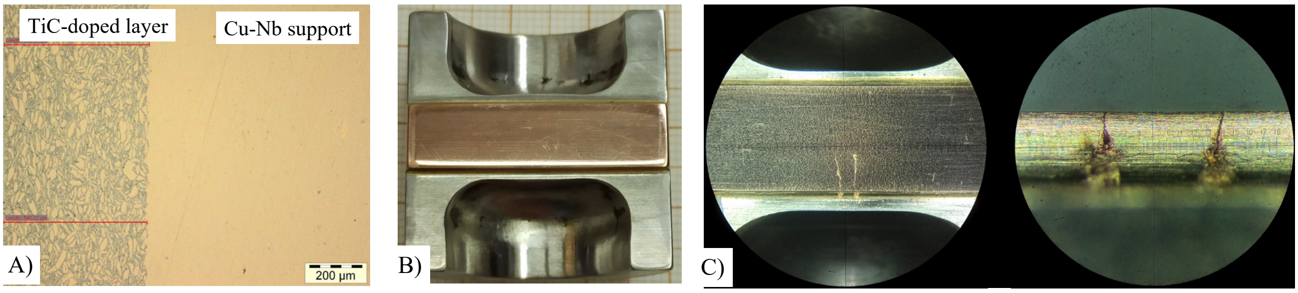

Fig. 1. Cross section of bi-layer structure (a), one part of duplex DFS with brazed sample (b), and (c) view of powder sample surface after 100 pulses of HMF (left – high-field working surface, right – side view)

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* The work was partly supported by the RFBR and BRFFR, RFBR and ROSATOM grants (Nos. 20-58-00029, 20-21-00050).