

# **Texture evolution during severe plastic deformation and residual stresses at low and high temperature of a copper matrix reinforced by niobium nanotubes**

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The development of reinforced conductors, with high electrical conductivity and high strength, is essential to provide non-destructive high pulsed magnetic fields over 80 Teslas: a compromise is obtained with Cu-based continuous nanofilamentary wires (2 GPa ultimate tensile strength and 0.6  $\mu\text{ohm.cm}$  electrical resistivity at 77K). The fabrication process of these nanocomposite wires is based on severe plastic deformation (SPD) applied by accumulative drawing and bundling, leading to a multi-scale copper matrix containing up to  $N=85^4$  ( $52.2 \cdot 10^6$ ) continuous and parallel niobium nanotubes.

Electron microscopy as well as laboratory x-ray diffraction experiments have been carried out on samples taken throughout the fabrication process to study the formation of microstructure, i.e. grain size and grain type distribution in Cu and Nb phases, as well as texture evolution. Nb nanotubes exhibit a rather homogeneous microstructure with strong  $\langle 110 \rangle$  axial texture and grains in the 100nm range. However, a complex microstructure was pointed out in the Cu matrix with different size and type of grains in the different Cu channels. The large Cu channels exhibit a microstructure similar to ultra fine grain Cu produced by other SPD techniques, with a majority of grains in the 200-400 nm range and grains remaining in the  $\mu\text{m}$  range, while the finest Cu channels (inter-tube and inner-tube Cu) are composed of only one or two grains between Cu/Nb interfaces. The formation of texture in Cu is analyzed with respect to the SPD steps and the occurrence of heat treatments and reveals two different states: the “deformation” texture (major  $\langle 111 \rangle$  fiber texture) and the “recrystallization” texture (major  $\langle 200 \rangle$  fiber texture). The texture of the final product is therefore the result of the interplay between these texture states and the grain size distribution.

In addition, neutron diffraction experiments have been performed on full wires at several temperatures (from 77K to 1073K) to measure the residual stresses in each phase of the nanocomposites. The observed complex residual stress state is related to the Cu-Nb co-deformation mechanisms and to the microstructure evolution imposed by the severe plastic deformation process.