Microstructure of Glidcop® AL-60 Conductor used in Pulsed Magnets

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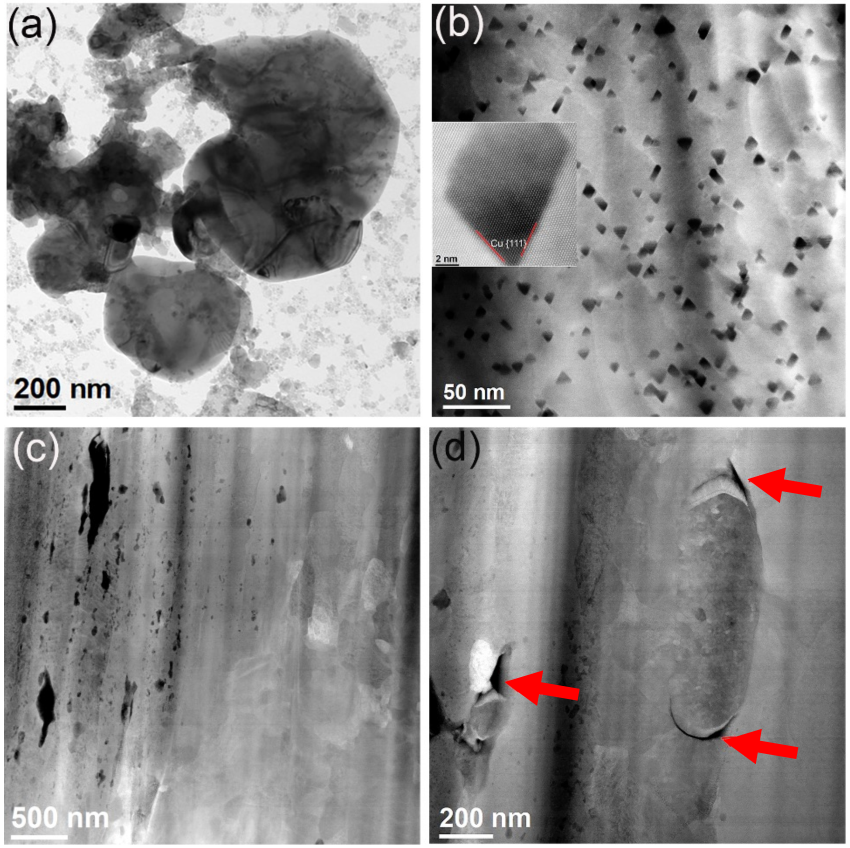
Pulsed magnets require conductors with both high mechanical strength and high electrical conductivity in order to achieve ultrahigh-magnetic fields. One of these conductors currently used in the MagLab's pulsed magnets is Glidcop® AL-60, a copper conductor strengthened by alumina (Al_2O_3) particles. The properties of these sorts of composite materials are often dictated by its microstructures. *As such, to understand the mechanical behavior of AL-60 and prevent unexpected magnet failure, magnet engineers and materials scientists must understand the microstructure of magnet conductors in detail*.

Transmission electron microscopy (TEM) and scanning transmission electron microscopy (STEM) image the microstructure of AL-60, in particular, the alumina particles that are responsible for the high mechanical strength. Researchers find a large range of alumina particle sizes, from 10nm to 500nm of two structural types: stable α-Al_2O_3 **(Fig. a)** and metastable cubic η-Al_2O_3. The η-Al_2O_3 nanoparticles were of triangular shape **(Fig. b)** with a well-defined crystal orientation relative to the Cu matrix.

Dislocations are observed around the η-Al_2O_3 particles, which suggests that dislocations were unable to cut through alumina particles during conductor deformation. Regions with no alumina particles **(Fig. c)** suggest local weak mechanical strength. *Finally, microcracks found near large α-Al_2O_3 particles **(Fig. d)** presumably reduce the fatigue life of the material, which can be a limiting factor in the lifetime of pulsed magnets*.



Electron microscope images of Glidcop® conductor, showing (a) the large α-Al_2O_3 particle; (b) the small η-Al_2O_3 particles; and (c) cold-drawn wire showing both a region of large Al_2O_3 particles of irregular shapes and a region with no Al_2O_3 particles.
(d) STEM image of microcracks associated with large Al_2O_3 particles after a tensile test of Glidcop® wire. Note that cracks form at the end of the particles, as indicated by the red arrows.

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