Heat Treatment Effects on Structure Evolution and Mechanical Properties of Cu-15Ni-8Sn

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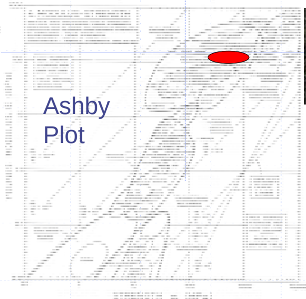
Abstract

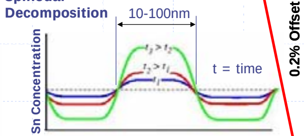
Certain spring applications require a material with a combination of high strength, stiffness, and electrical conductivity. An alloy consisting of 77 weight percent copper, 15 weight percent nickel, and 8 weight percent tin, formed via a powder metallurgy process, is one of several copper-based alloys which can be heat treated/processed to form a metallic nano-structured alloy with good combinations of yield strength and electrical conductivity. For certain heat treatment conditions, this alloy decomposes spinodally from a face centered cubic disordered phase to form tin-rich and tin-lean composition fluctuations that are only 10-100nm thick. Additional time at temperature produces ordering of the tin-rich regions. Uniaxial tensile tests have been used to identify the aging conditions with the highest yield strength. The tensile properties of the various heat-treated conditions will be compared with observed fracture surfaces in an effort to characterize the failure mechanisms of the various time and temperature evolved microstructures. The mechanical properties are being correlated with microstructural information obtained from a variety of different techniques. Optical metallography, transmission electron microscopy, resistivity measurements, differential scanning calorimetry traces and X-Ray diffraction spectra are included in order to map the evolution of specific micro- and nano-structural features with various heat treatments. Support for this research has been provided by the National Physical Sciences Consortium. and Case Prime Fellowship.

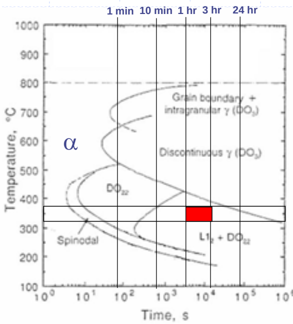
Potential Application: Electrical Springs



Ashby Plot

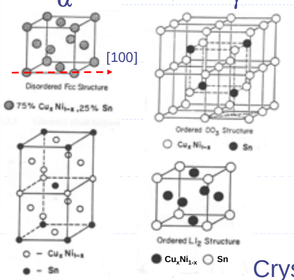
Desired Properties
- High Strength
- High σ_y/E
- Low resistivity





TTT Curve

Region of interest for peak strength



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Crystal Structures

Current Materials Tested

Alloy Chemistry: Cu-15.0Ni-8.0Sn

Pressed and Sintered Elemental Powders, Cold Rolled

Solutionized (800°C) / Water Quench

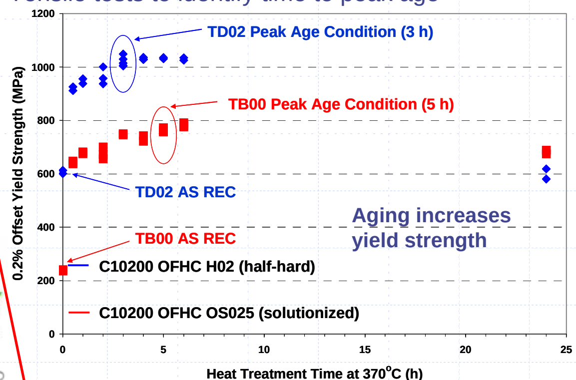
→ TB00 As Received

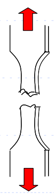
Cold Rolled → TD02 As Received

Strip
0.152 mm thick
25 mm wide

Heat treatments + Knoop hardness tests on longitudinal cross section to suggest peak age temperature (370°C)

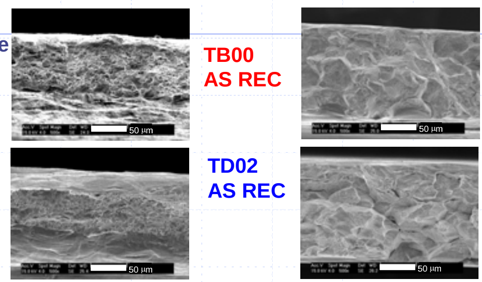
Tensile tests to identify time to peak age





Tensile Test
ASTM E8
Gage = 25.4 mm

Aging changes fracture surface



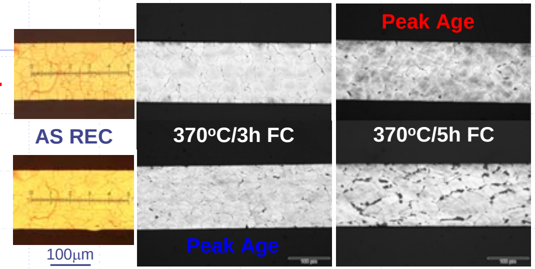
TB00 AS REC

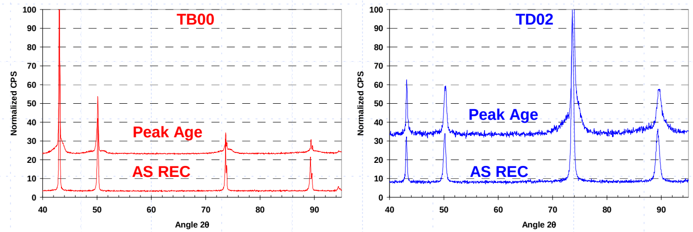
TB00 Peak Age

TD02 AS REC

TD02 Peak Age

Microstructure





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