TERNARY HIGH-STRENGTH Cu-BASED IN-SITU METAL MATRIX COMPOSITES

MAX-PLANCK PROJECT REPORT

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Project References

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„Rolling textures of a Cu-20%Nb composite“

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„Correlation of superconductivity and microstructure in an in-situ formed Cu-20%Nb composite“

„Textures of rolled and wire drawn Cu-20% Nb“

U. Hangen, D. Raabe: physica status solidi (a) 147 (1995) 515–527
„Experimental investigation and simulation of the normal conducting properties of a heavily cold rolled Cu-20mass% Nb in situ composite“

„Observation of amorphous areas in a heavily cold rolled Cu-20wt.% Nb composite“

„On the correlation of microstructure and electromagnetic properties of heavily cold worked Cu-20 wt.% Nb wires“

„Investigation of a Cu-20mass%Nb in situ Composite Part I: Fabrication, Microstructure and Mechanical Properties Part II: Electromagnetic Properties and Application“

„Modelling of the yield strength of a heavily wire drawn Cu-20%Nb composite by use of a modified linear rule of mixtures“
„Correlation of microstructure and type II superconductivity of a heavily cold rolled Cu-20mass% Nb in situ composite“

„On the anisotropy of the superconducting properties of a heavily cold rolled Cu-20 mass% Nb in situ composite“

„Microstructure and mechanical properties of a cast and wire drawn ternary Cu-Ag-Nb in situ composite“

„Experimental investigation and Ginzburg–Landau modeling of the microstructure dependence of superconductivity in Cu–Ag–Nb wires“

„Experimental investigation and modeling of the influence of microstructure on the resistive conductivity of a Cu–Ag–Nb in situ composite“

„Application of In Situ-Formed Metallic-Fiber-Reinforced Copper Matrix Composites to Cables Used for Robots“

„Processing, microstructure, and properties of ternary high–strength Cu–Cr–Ag in situ composites“
Project details

Cu and most high melting body centered cubic (bcc) transition metals have negligible mutual solubility by practical means. Fibre or ribbon reinforced in-situ metal matrix composites (MMCs) can thus be processed by large degrees of deformation, e.g. by cold rolling or wire drawing of cast ingots. These Cu-bcc alloys are of considerable interest since after heavy deformation very high tensile strength combined with good electrical conductivity can be achieved. Furthermore, fundamental aspects such as the origin of the extreme strength attract much attention.

In the last years substantial efforts were made to investigate and optimize alloys based on the binary systems of Cu with Nb (bcc) or Cr (bcc). Additional investigations addressed in-situ MMCs that are based on the eutectic system of Cu and Ag (fcc). While in the first case the fibers are formed by the elongated body centered cubic phase ( Nb, Cr), in the second case Ag precipitations were used to increase the matrix strain and / or to form additional fibers after wire drawing or rolling.

The present Max-Planck project deals with the experimental investigation and theoretical prediction of a new generation of composites that combine both mechanisms. These alloys which have a high electrical conductivity and a high strength are based on the ternary systems Cu - Nb - Ag and Cu - Cr - Ag.
The diagram shows the relationship between wire strain ($\eta$) and ultimate tensile strength [MPa] for three different copper alloys:

- Cu-20\%Nb
- Cu-4\%Nb-8\%Ag
- Cu-10\%Cr-3\%Ag

The ultimate tensile strength is calculated from HV. The graph includes data points and lines for each alloy, demonstrating how the tensile strength increases with wire strain.
Ultimate tensile strength of Cu-8.2 mass% Ag-4 mass% Nb and two Cu-20 mass% Nb alloys with different Nb dendrite diameters in the as-cast state.
Evolution of the Cr and Nb filaments during wire drawing of Cu-Cr-Ag and Cu-Nb-Nb-Ag.
Transition of the Cu-Ag-Nb MMC to the superconducting state
Relative change in resistivity as a function of wire strain due to the size effect
Resistivity of the Cu-Ag-Nb MMC.