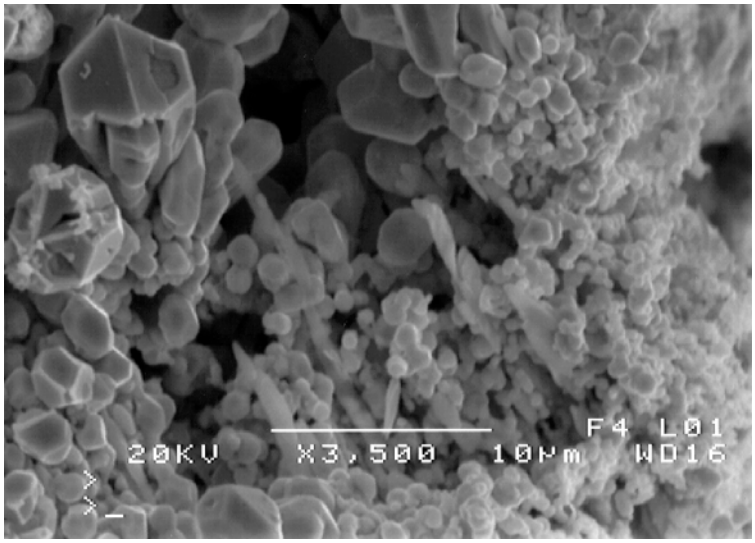
TERNARY HIGH-STRENGTH CU-BASED IN-SITU METAL MATRIX COMPOSITES

MAX-PLANCK PROJECT REPORT

D. Raabe

Max-Planck-Institut für Eisenforschung
Max-Planck-Str. 1
40237 Düsseldorf
Germany

März 2004, Max-Planck-Society
*http://*www.mpg.de *http://*www.mpie.de *http://edoc.mpg.de/*



Project References

D. Raabe, J. Ball, G. Gottstein: Scripta Metall. 27 (1992) 211–216
„Rolling textures of a Cu-20%Nb composite“

D. Raabe, F. Heringhaus: physica status solidi (a) 142 (1994) 473–481
„Correlation of superconductivity and microstructure in an in-situ formed Cu-20%Nb composite“

F. Heringhaus, U. Hangen, D. Raabe, G. Gottstein: Materials Science Forum 157–162 (1994) 709–714.
„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“

D. Raabe, U. Hangen: Materials Letters 22 (1995) 155–161
„Observation of amorphous areas in a heavily cold rolled Cu-20wt.% Nb composite“

F. Heringhaus, D. Raabe, G. Gottstein: Acta Metall. 43 (1995) 1467–1476
„On the correlation of microstructure and electromagnetic properties of heavily cold worked Cu-20 wt.% Nb wires“

D. Raabe, F. Heringhaus, U. Hangen, G. Gottstein: Zeitschrift für Metallkunde 86 (1995) 405–422
„Investigation of a Cu-20mass%Nb in situ Composite
Part I: Fabrication, Microstructure and Mechanical Properties
Part II: Electromagnetic Properties and Application“

U. Hangen, D. Raabe: Acta Metall 43 (1995) 4075–4082
„Modelling of the yield strength of a heavily wire drawn Cu-20%Nb composite by use of a modified linear rule of mixtures“

D. Raabe, U. Hangen: Acta metall. 44 (1996) 953–961
„Correlation of microstructure and type II superconductivity of a heavily cold rolled Cu-20mass% Nb in situ composite“

D. Raabe, U. Hangen: physica status solidi (a) 154 (1996) 715–726
„On the anisotropy of the superconducting properties of a heavily cold rolled Cu-20 mass% Nb in situ composite“

D. Raabe, D. Mattissen: Acta Materialia 46 (1998) 5973–5984
„Microstructure and mechanical properties of a cast and wire drawn ternary Cu-Ag-Nb *in situ* composite“

D. Raabe, D. Mattissen: Acta Materialia 47 (1999) 769–777
„Experimental investigation and Ginzburg–Landau modeling of the microstructure dependence of superconductivity in Cu–Ag–Nb wires“

D. Mattissen, D. Raabe, F. Heringhaus: Acta Materialia 47 (1999) 1627–1634
„Experimental investigation and modeling of the influence of microstructure on the resistive conductivity of a Cu–Ag–Nb in situ composite“

K. Miyake, N. Hanzawa, H. Takahara, S. Kobayashi, D. Raabe: Japanese Jornal of Applied Physics 39 (2000) 119-121
„Application of In Situ-Formed Metallic-Fiber-Reinforced Copper Matrix Composites to Cables Used for Robots “

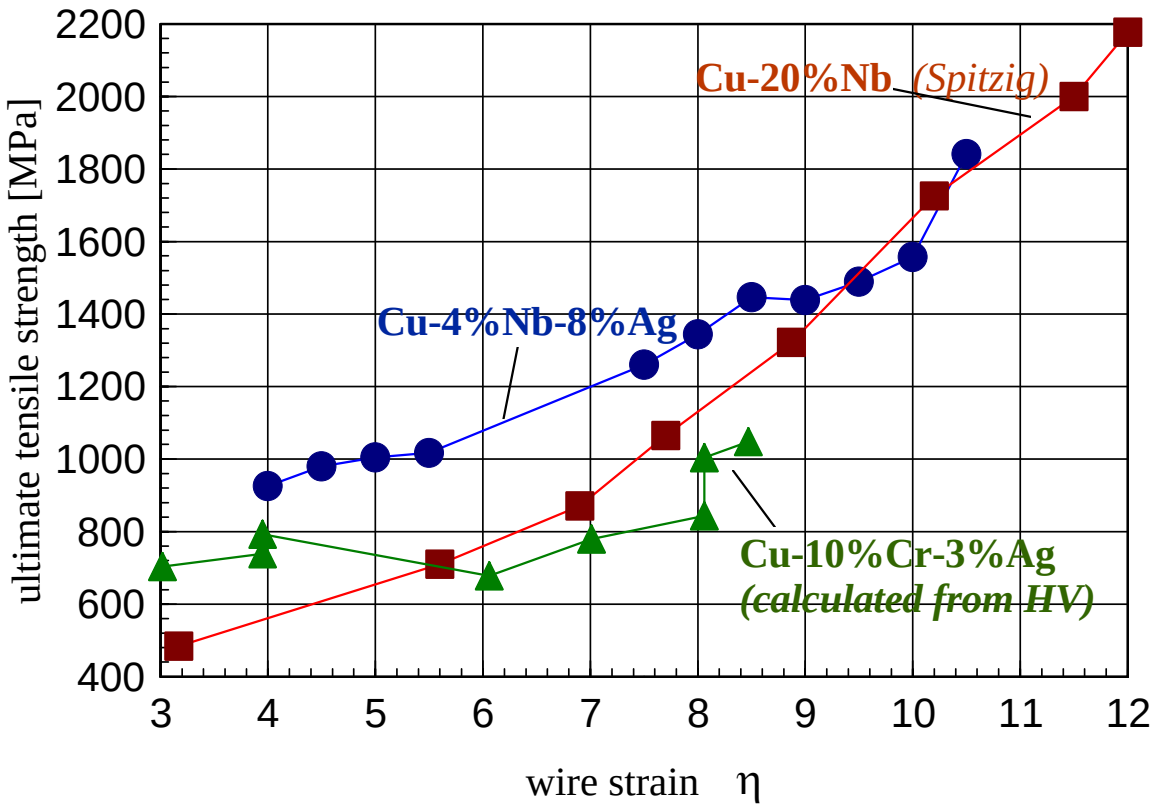
D. Raabe, K. Miyake, H. Takahara: Material Science and Engineering, A 291 (2000) 186-197
„Processing, microstructure, and properties of ternary high–strength Cu–Cr–Ag in situ composites“

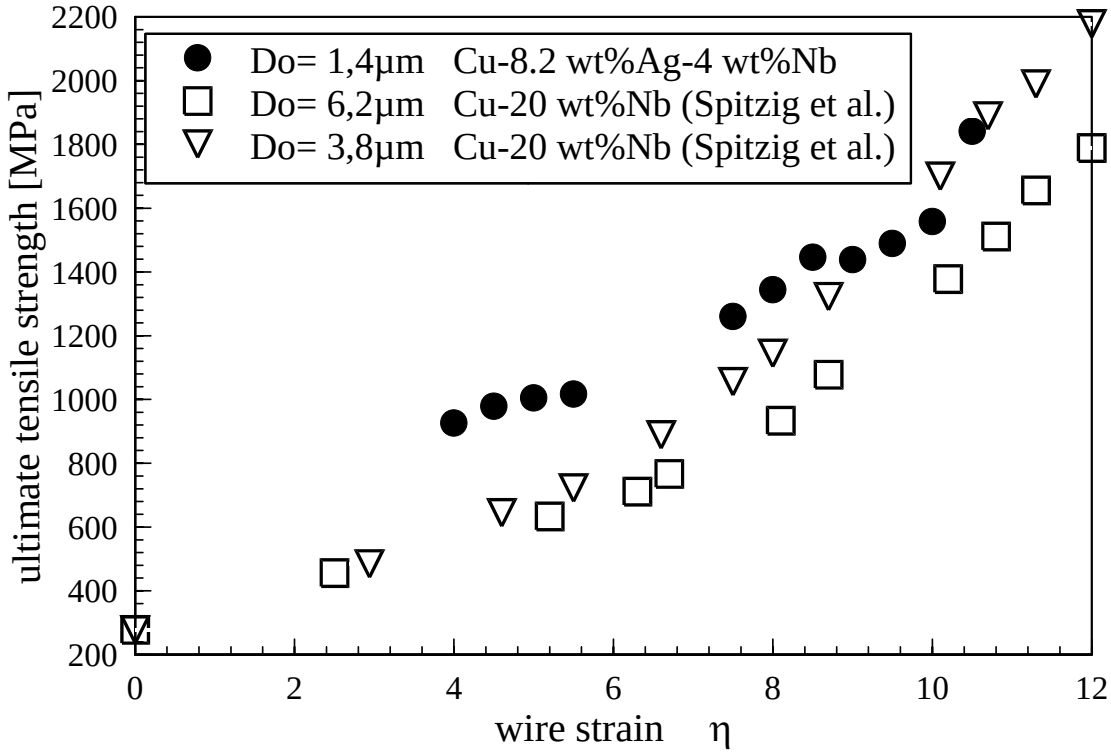
Project details

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.

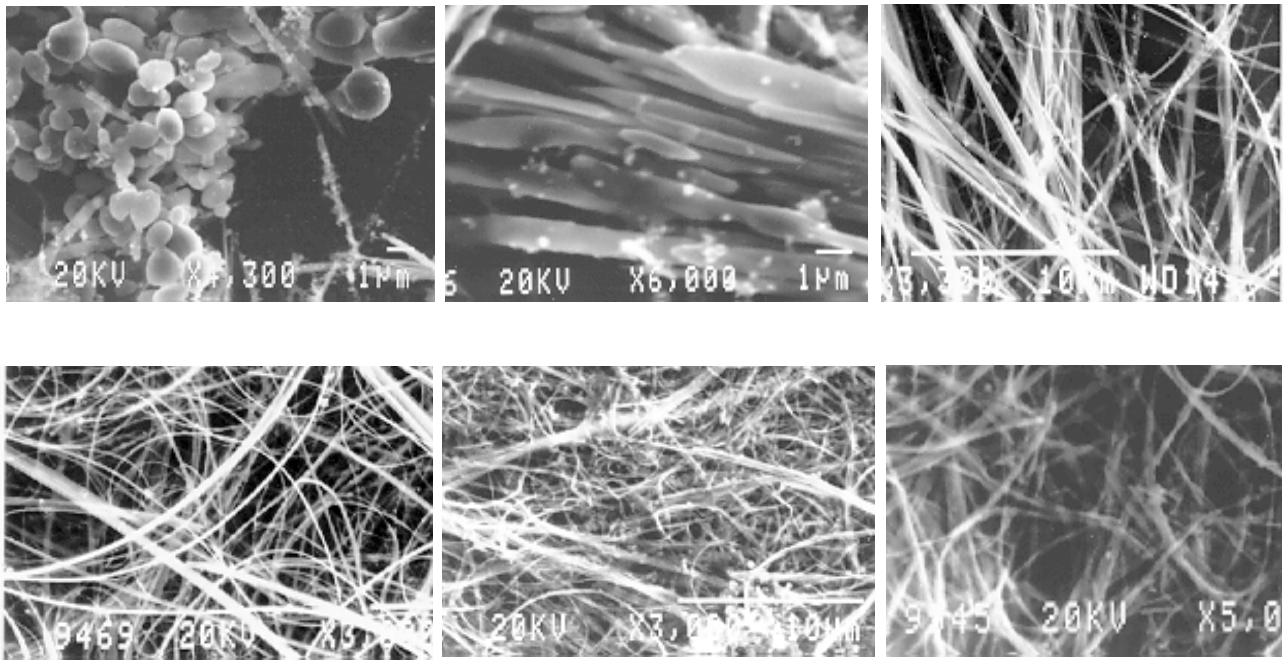
In the last years substantial efforts were made to investigate and optimize alloys based on the binary systems of Cu with Nb (bcc) or Cr (bcc). Additional investigations addressed in-situ MMCs that are based on the eutectic system of Cu and Ag (fcc). While in the first case the fibers are formed by the 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.

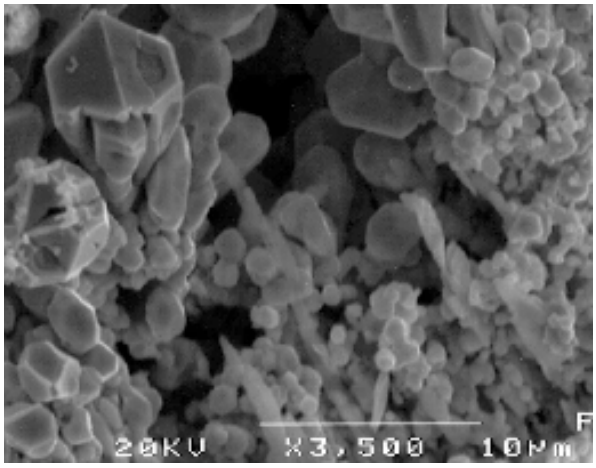
The present Max-Planck project deals with the experimental investigation and theoretical prediction of a new generation of composites that combine both mechanisms. These alloys which have a high electrical conductivity and a high strength are based on the ternary systems Cu - Nb - Ag and Cu - Cr - Ag.

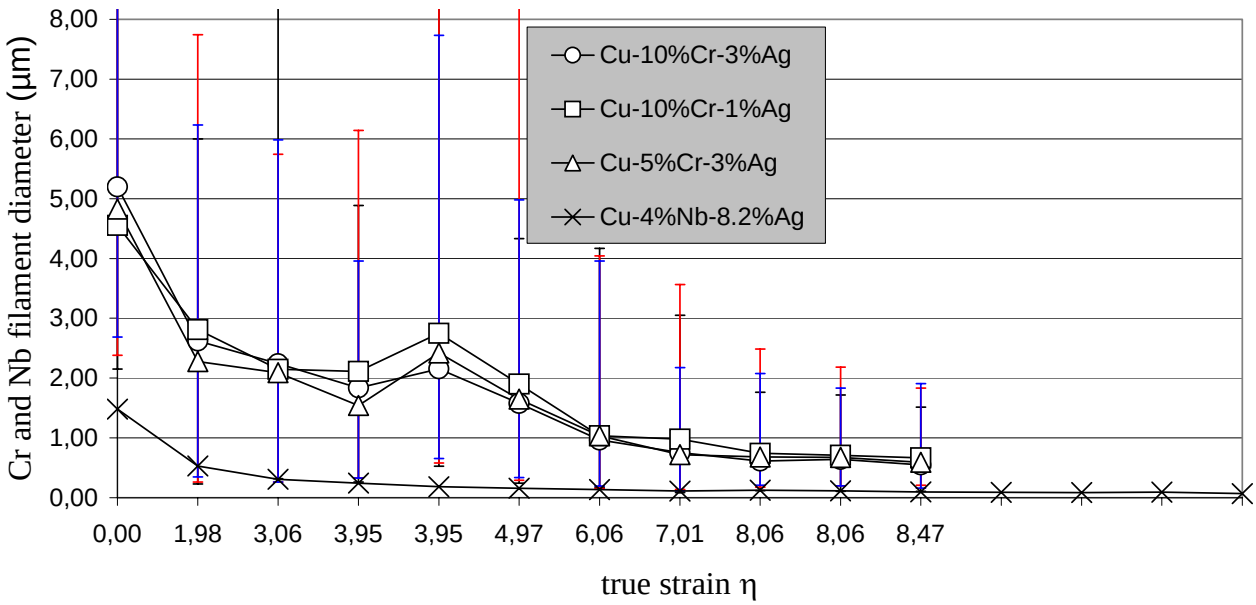

ultimate tensile strength [MPa]
2200
2000
1800
1600
1400
1200
1000
800
600
400
3
4
5
6
7
8
9
10
11
12
wire strain η
Cu-20%Nb (Spitzig)
Cu-4%Nb-8%Ag
Cu-10%Cr-3%Ag
(calculated from HV)



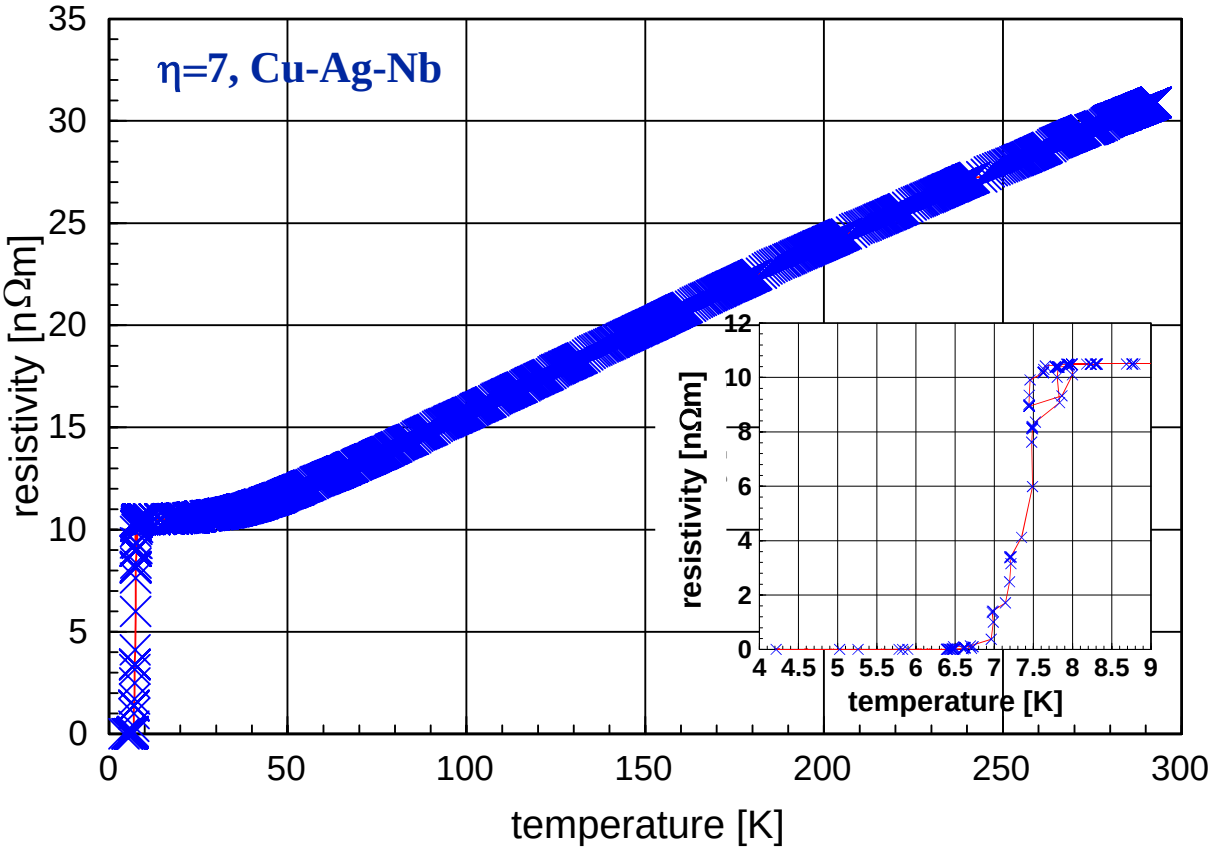
Ultimate tensile strength of Cu-8.2 mass% Ag-4 mass% Nb and two Cu-20 mass% Nb alloys with different Nb dendrite diameters in the as-cast state.



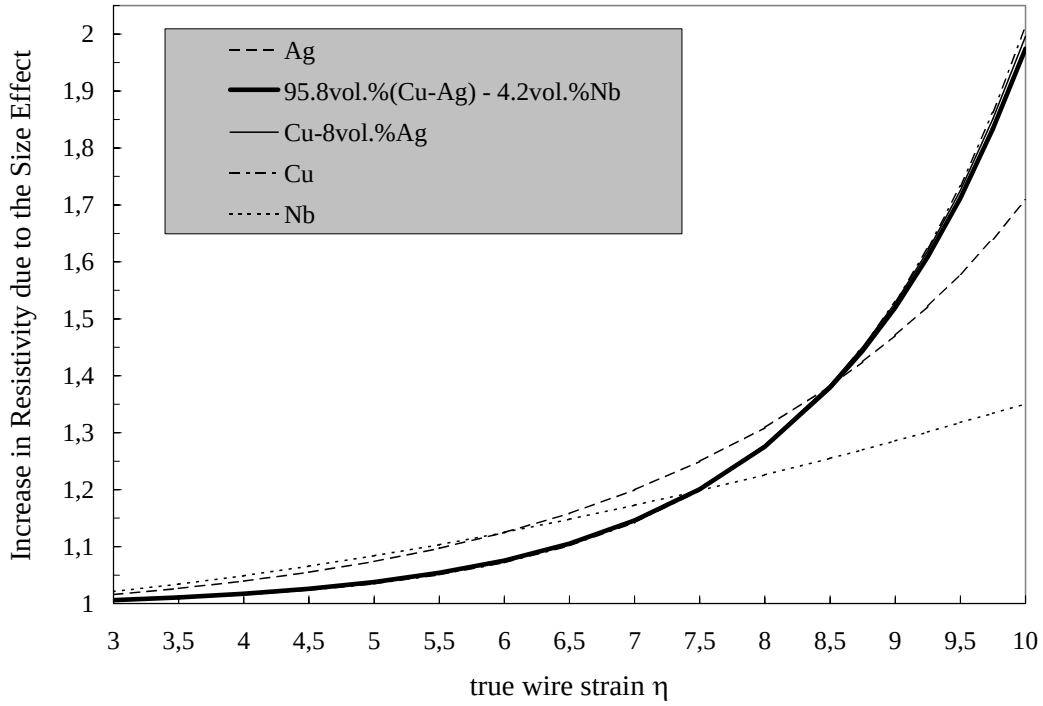




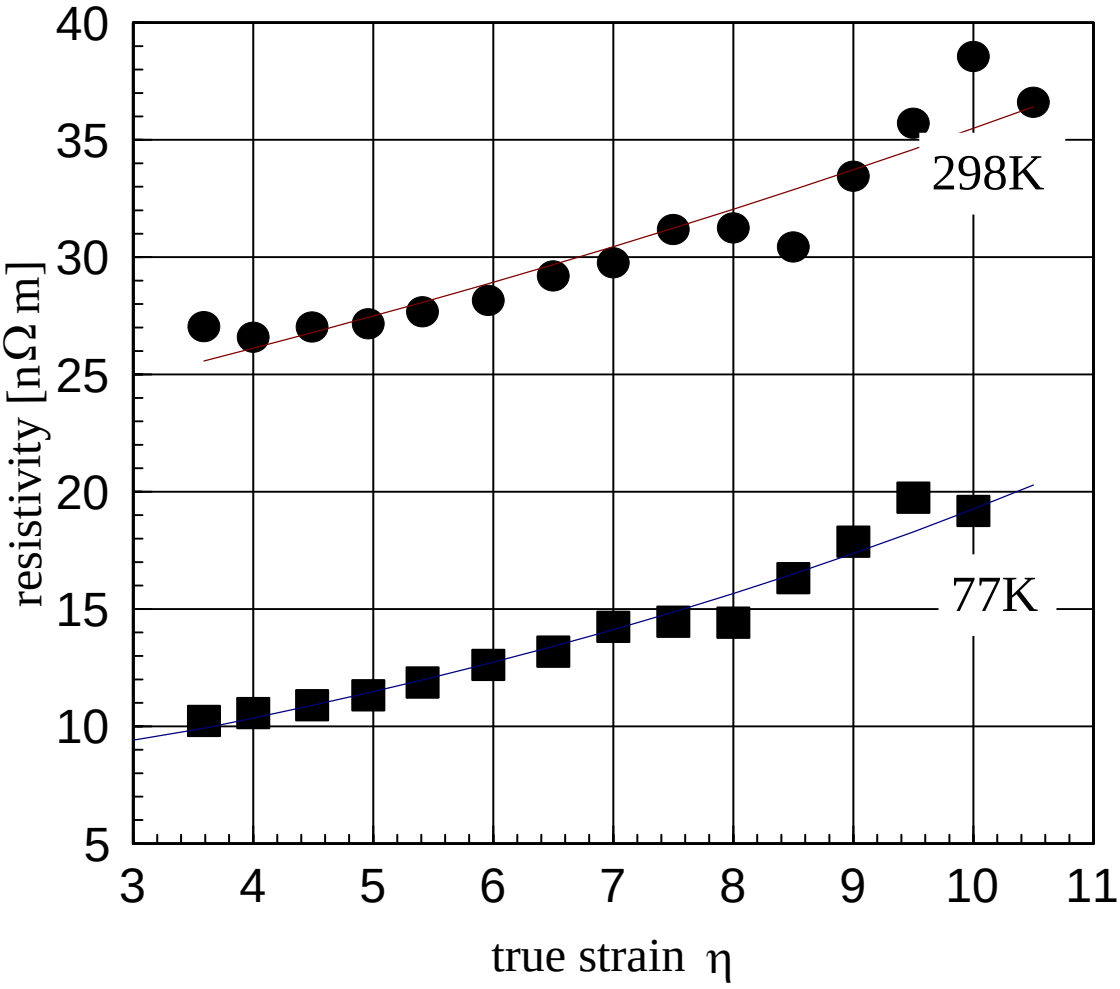
Evolution of the Cr and Nb filaments during wire drawing of Cu-Cr-Ag and Cu-Nb-Nb-Ag.



Transition of the Cu-Ag-Nb MMC to the superconducting state



Relative change in resistivity as a function of wire starin due to the size effect



Resistivity of the Cu-Ag-Nb MMC.