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Ag nanowires - Cu composite wires for non-destructive pulsed fields : importance of avoiding the formation of a Ag/Cu alloy relative to the electrical resistivity and the tensile strength

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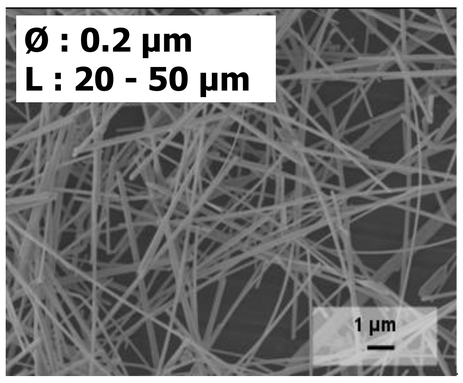
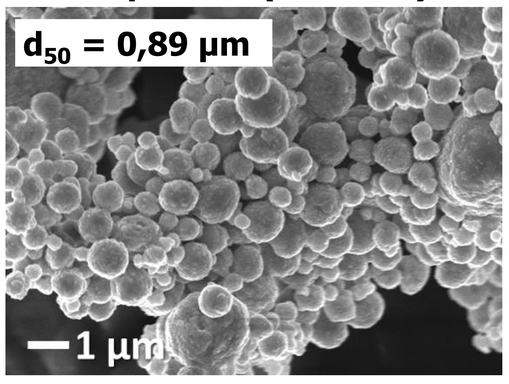
COMPOSITE POWDERS

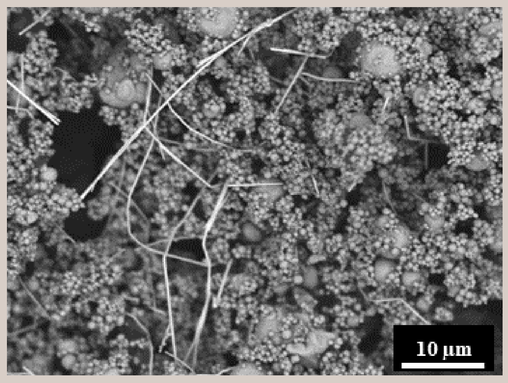
Lab made (CIRIMAT) Ag nanowire (99.9999 %)



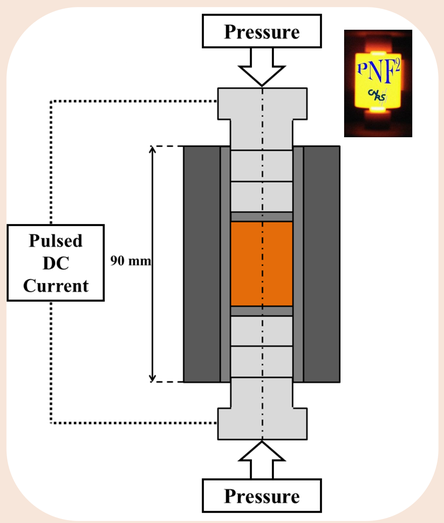
Commercial spherical Cu powder (99.99 %)



1 vol.% Ag-Cu composite powder (14 g)

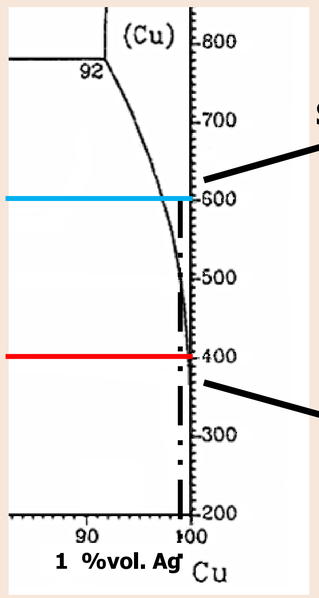


CONSOLIDATION BY SPARK PLASMA SINTERING



SPS parameters :
400 or 600 °C
25 MPa ; 5 min

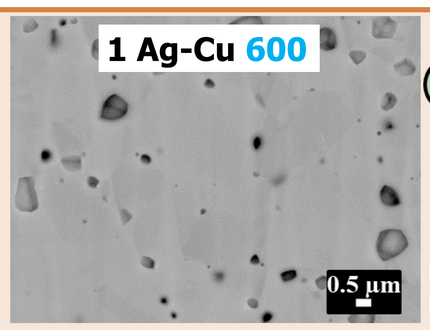
Densification 94 ± 2 %

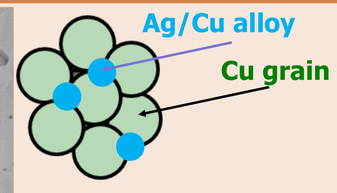


SPS

at 600 °C
Ag solubility in Cu 2.4 vol.%

5 min at 600 °C
L_{diff} = 232 nm



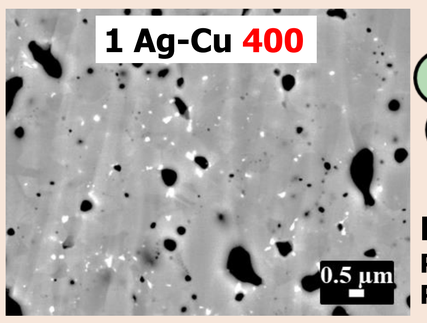


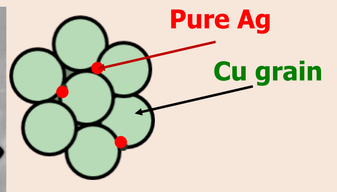
Microstructure :
Pure Cu matrix
Localized Cu/Ag Alloy

SPS

at 400 °C
Ag solubility in Cu < 0.1 vol.%

5 min at 400 °C
L_{diff} = 0.24 nm





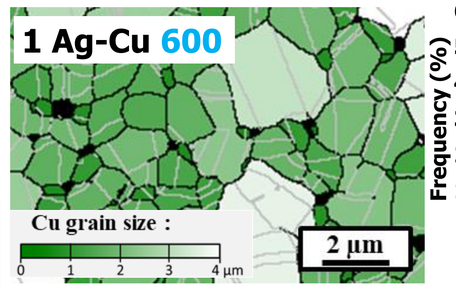
Microstructure :
Pure Cu matrix
Pure Ag

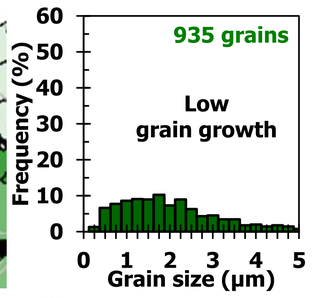
SPS CYLINDER AND FINE WIRE MICROSTRUCTURE

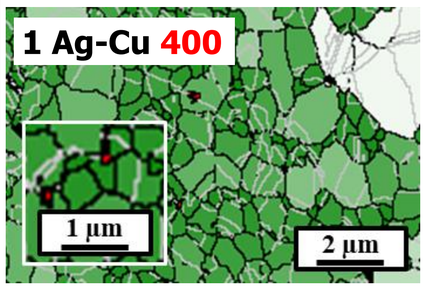
Ø 8 mm

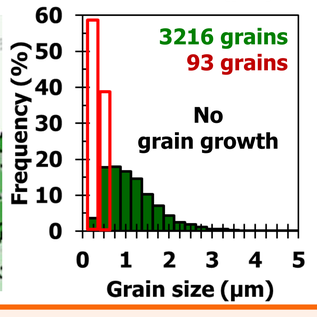
SPS cylinder

Cu
Ag

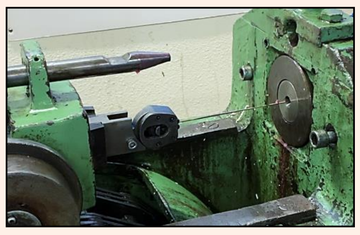






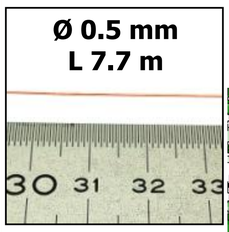


Wire Drawing

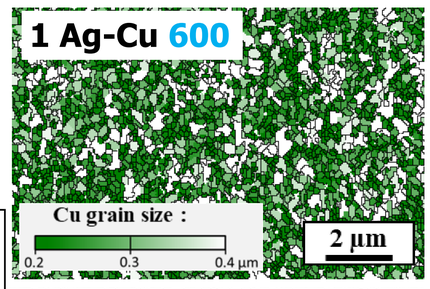


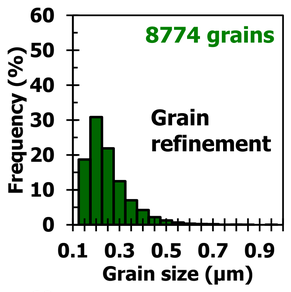
Ø 0.5 mm

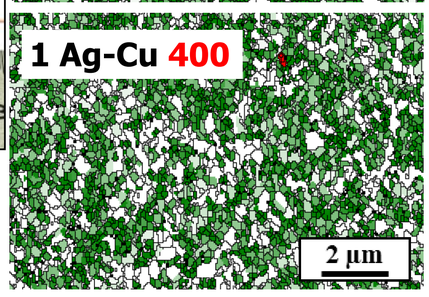
Fine wire

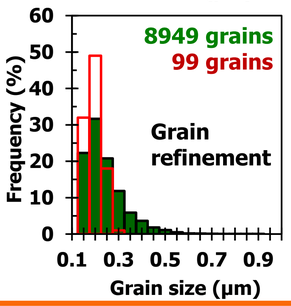


Cu
Ag

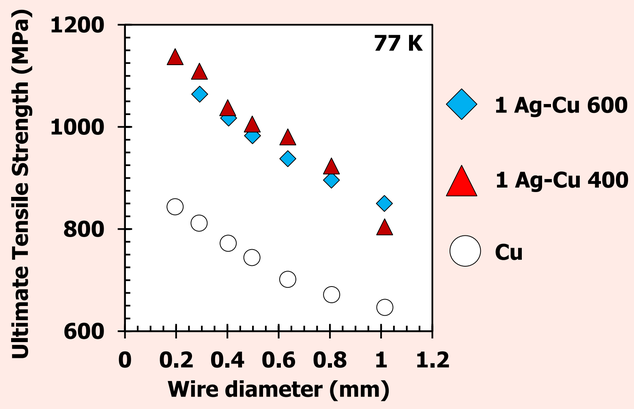


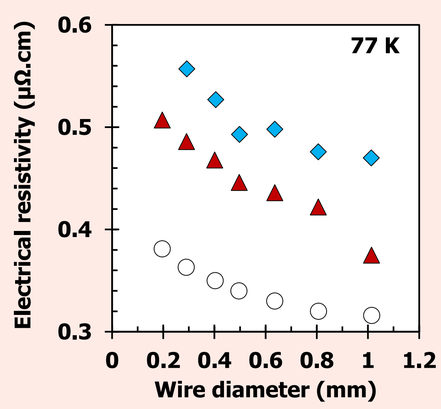


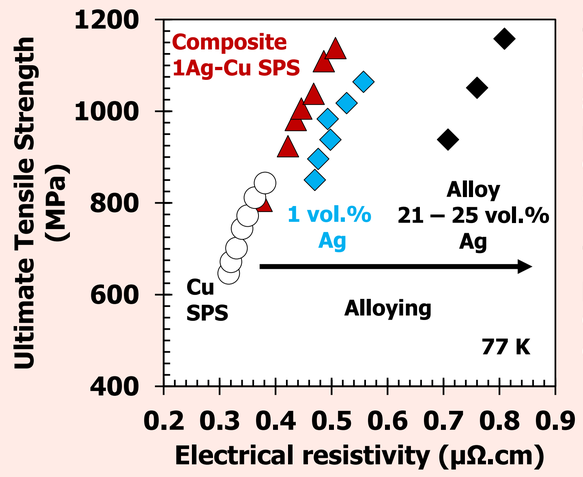




MECHANICAL AND ELECTRICAL PROPERTIES







The **composite** and **alloy** wires show similar UTS values (1100 MPa at 77 K), significantly higher than for pure Cu, reflecting an equivalent strengthening effect by the **pure Ag** and the **Cu/Ag alloy**.

The **alloying** is not widespread but provokes a significant increase in electrical resistivity compared to the **composite wires**.

CONCLUSIONS

The formation of a Ag/Cu alloy in 1Ag-Cu600 significantly degrades the electrical resistivity (0.56 µΩ.cm at 77 K) compared to the 1Ag-Cu400 wire (0.49 µΩ.cm at 77 K). This confirms the importance to obviate alloying during both the design and process of the wires and to remain as close as possible to pure Cu.

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SIgMA Project
Projet n°ANR-20-CE08-0027-01