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Microstructure and properties of cold drawing Cu-2.5% Fe-0.2% Cr and Cu-6% Fe alloys

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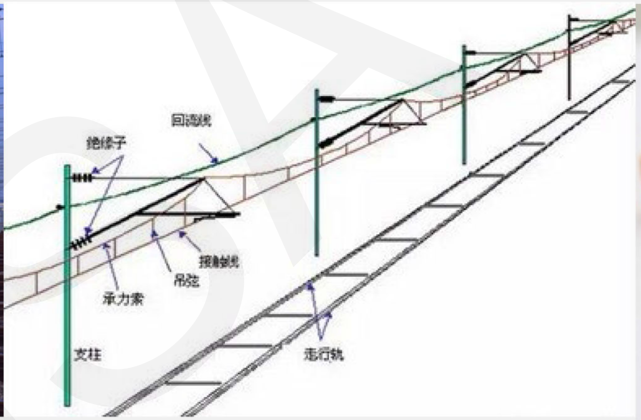
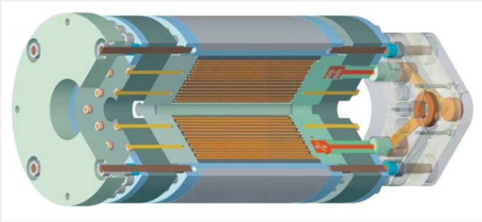
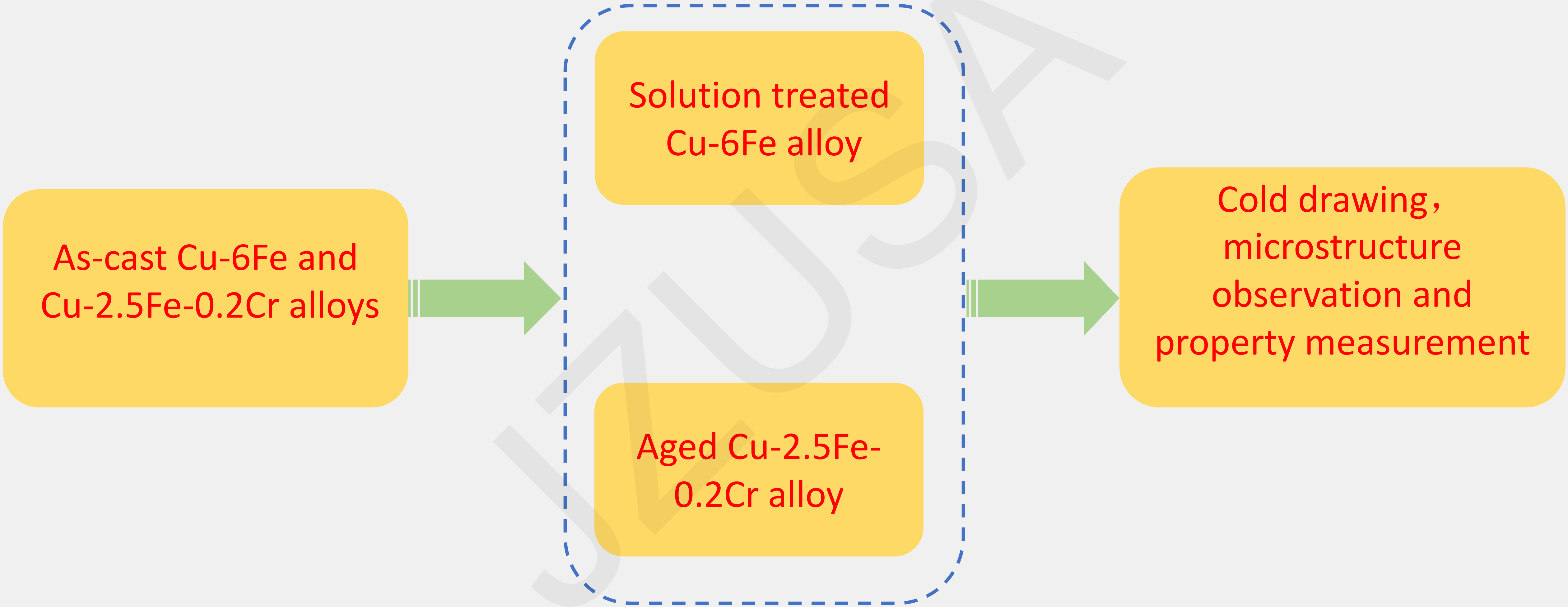
Application of high-strength high-conductivity Copper base materials

The high-strength high conductivity Cu-base materials is used as conductor materials in high-field magnet and high-speed railway.





Materials and method



Results

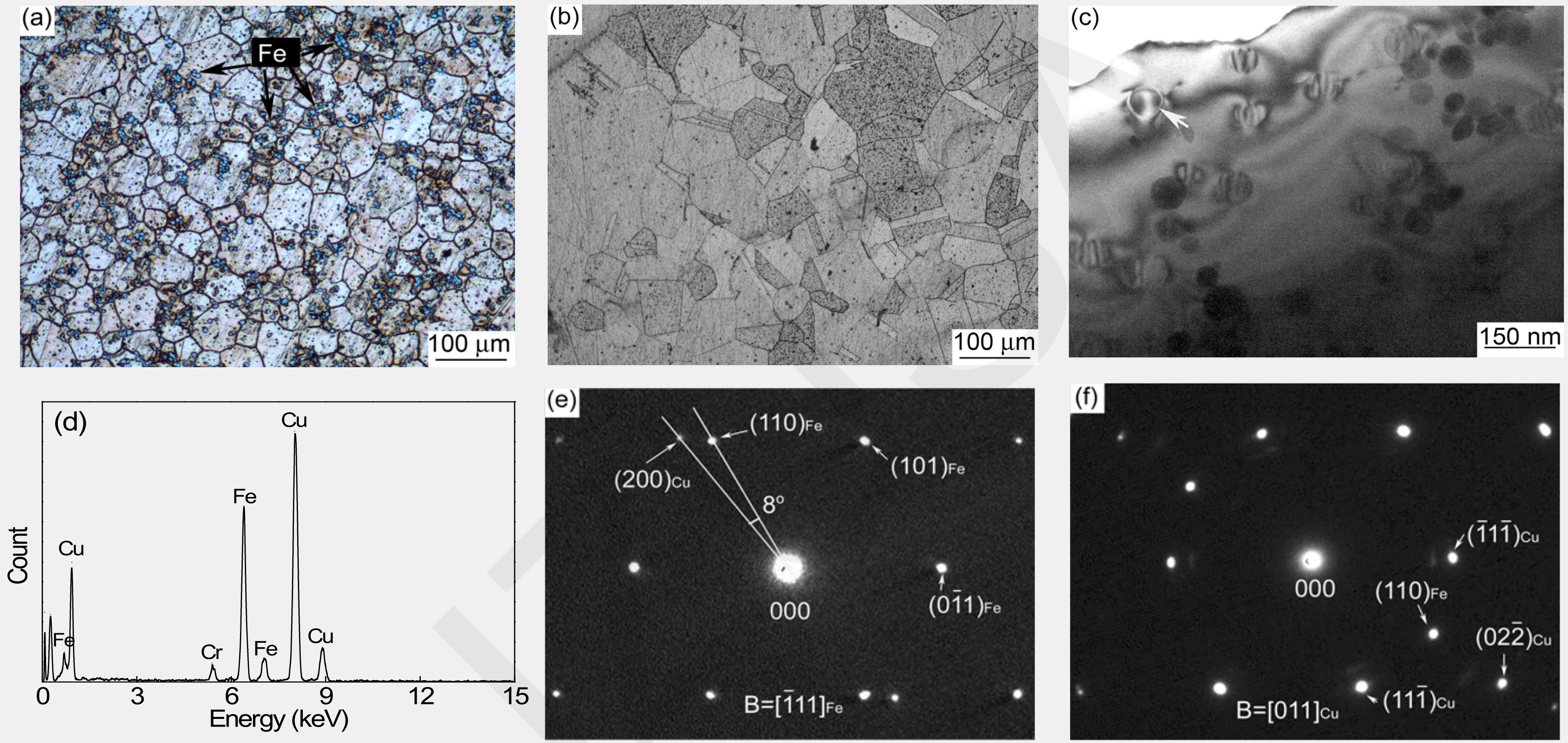


Fig. 1 Optical images of solution treated Cu-6% Fe (a) and aged Cu-2.5% Fe-0.2% Cr (b), TEM image of aged Cu-2.5% Fe-0.2% Cr (c), EDS spectra of a precipitate particle pointed by white arrow in Fig. 1c (d), and SAED patterns of Cu matrix and Fe particles when the electron beam is almost parallel with (e) and $[011]_{Cu}$ (f)

Results

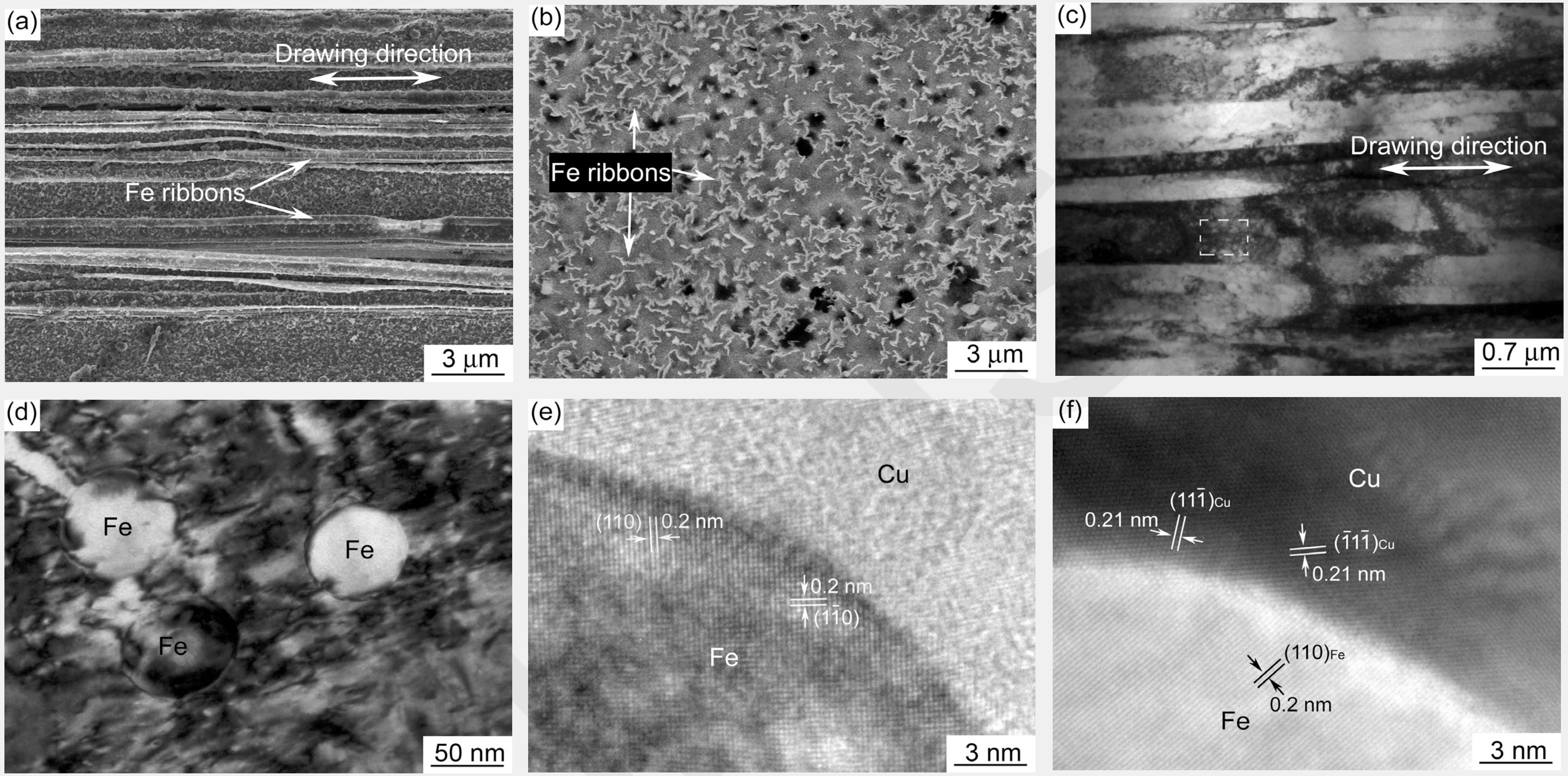


Fig. 2 SEM images of Cu-6% Fe at η=6 longitudinal section (a) and transversal section (b), TEM images of Cu-2.5% Fe-0.2% Cr at η=6 low magnification of longitudinal section (c) and high magnification of Fe precipitate particles in the white rectangle in Fig. 2c (d), and HRTEM images of a Fe precipitate particle embedded in Cu matrix when the electron beam is almost parallel with $[100]_{Fe}$ (e) and $[011]_{Cu}$ (f)

Results

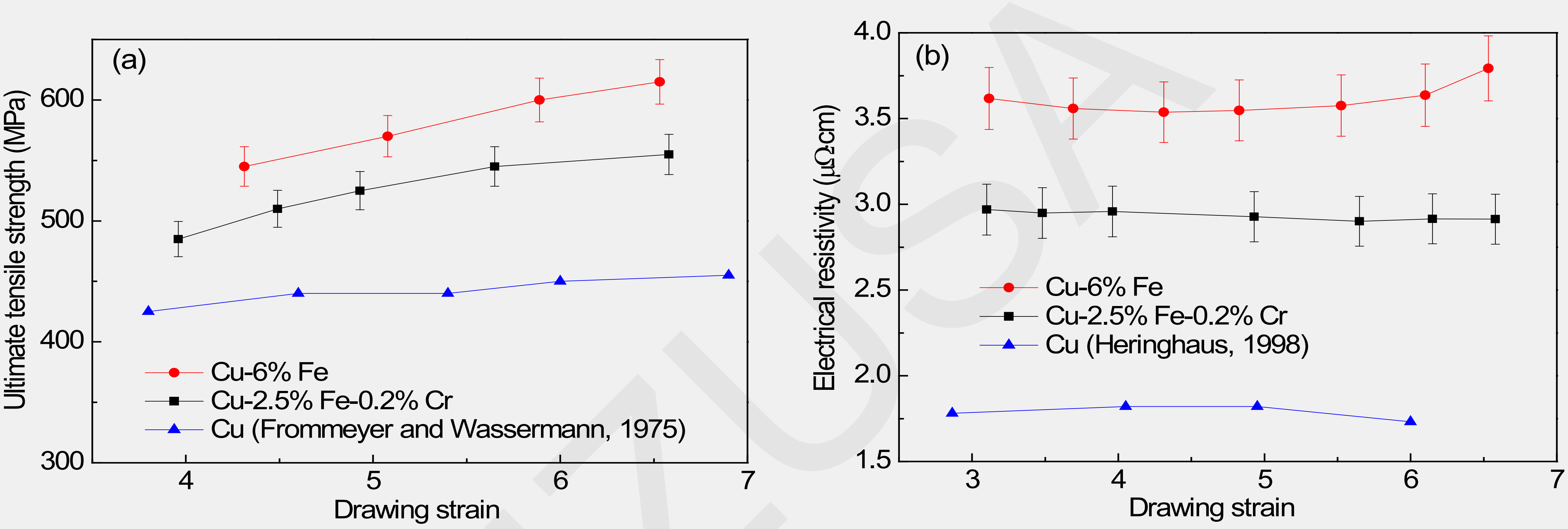


Fig. 3 Ultimate tensile strength (a) and electrical resistivity (b) of Cu-2.5% Fe-0.2% Cr, Cu-6% Fe, and pure Cu (Frommeyer and Wassermann, 1975; Heringhaus, 1998) dependent on the drawing strain

Conclusions

- Fe primary particles with a size of about 5 μm were produced in the Cu-6% Fe alloy by solution treatment. Fe precipitate particles with a size of about 50 nm were produced in the Cu-2.5% Fe-0.2% Cr alloy by a solution and aging treatment.

- During the cold drawing, Fe primary particles were elongated and evolved into nano-scaled ribbons. The density of the Cu/Fe phase interface gradually increases with the drawing strain. As a result, the strength and the electrical resistivity of the Cu-6% Fe alloy also increases with the drawing strain.

- In contrast, the Fe precipitate particles were hardly deformed and kept their spherical morphology even at η=6. High density of dislocation surrounds the Fe precipitate particles. The strength of the Cu-2.5% Fe-0.2% Cr alloy increases with the increase of the drawing strain and can be described by the Orowan mechanism. The electrical resistivity of the Cu-2.5% Fe-0.2% Cr alloy keeps almost constant since the density of the Cu/Fe phase interface shows hardly any change during cold drawing.

- The size effect and the incoherent interface of the Fe precipitate particles and Cu matrix play primary roles in the unchanging of Fe precipitate particles during cold drawing.