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Deformation mechanisms and structure-property relations of drawn tungsten wires

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Tungsten (W) shows a pronounced transition from ductile deformation behaviour at high temperatures to brittle behaviour at low temperatures (ductile-to-brittle transition). Undeformed, coarse-grained W exhibits transition temperatures (T_{DBT}) around 200 °C to 300 °C, rendering it unsuitable for structural applications at room temperature. The transition is shifted to lower temperatures by cold-working W in wire drawing, rolling or a severe plastic deformation process. Sufficiently cold-worked W materials deform plastically at room temperature and below. The reasons for the shift of T_{DBT} are connected to the deformation-induced microstructural changes. We performed the first systematic study of the relationship between microstructure and deformation mechanisms on a series of sequentially drawn potassium-doped W wires. The deformation behaviour and the strength of the wires were investigated using tensile tests at room and elevated temperatures as well as transient mechanical tests; the microstructure was characterised using electron backscatter diffraction (EBSD) and X-ray diffraction (XRD). The study aims at providing an extensive database that allows for the formulation of structure-property relations and facilitates the deduction of the effective deformation mechanisms in worked W wires. Special focus is directed to the particular wire condition marking the transition from brittle to ductile deformation at room temperature.

Keywords: Tungsten, cold-working, deformation, structure-property relations, ductility

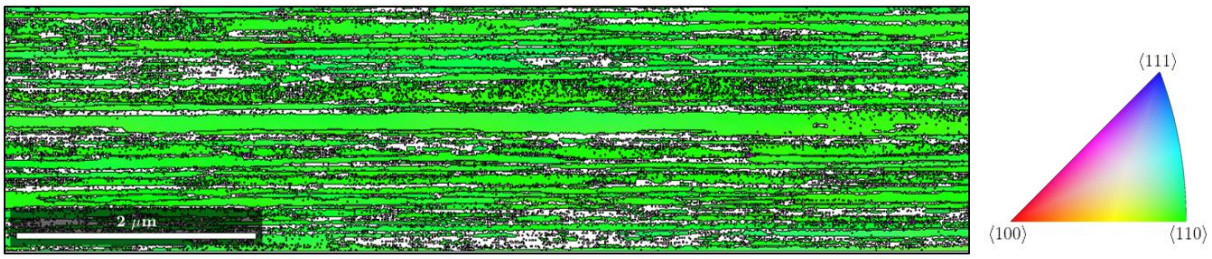

Fig.1: Orientation map illustrating the elongated grain structure of a drawn W wire with a diameter of 41 µm. The coloring of crystallographic directions according to the horizontal wire axis reveals the existence of a strong <110> fiber texture of the wire.