Dislocation-based plasticity and strengthening mechanisms in sub-20 nm lamellar structures in pearlitic steel wire - DTU Orbit (09/11/2017)

Dislocation-based plasticity and strengthening mechanisms in sub-20 nm lamellar structures in pearlitic steel wire

The tensile properties and the deformation microstructure of pearlitic steel (0.8 wt % C) have been quantified in wires drawn to strains in the range from 3.7 to 5.4, having a flow stress in the range from 3.5 to 4.5 GPa. With increasing strain the interlamellar spacing (ILS) decreases from about 20 to 10 nm and the thickness of the cementite lamellae decreases from about 2 nm to about 0.7 nm, representing a structure, which breaks up at large strains, decomposes and releases carbon to the ferrite lamellae. The dislocation density increases continuously with strain and reaches about 5 1016 m2 at a strain of 5.4; the dislocations are stored as threading dislocations, as dislocation tangles and as cell boundaries with low to medium misorientation angles. An analysis of the evolution of microstructure and strength with increasing strain suggests that dislocation-based plasticity is a dominating mechanism in the wire and three strengthening mechanisms are applied: boundary strengthening, dislocation strengthening and solid solution hardening with their relative contributions to the total flow stress which change as the strain is increased. Based on linear additivity good correspondence between the calculated and the measured flow stress is observed over the strain range 0e5.4. However at large strains beyond 3.7 deviations are observed which are discussed in terms of the applied strength-structure relationships.

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