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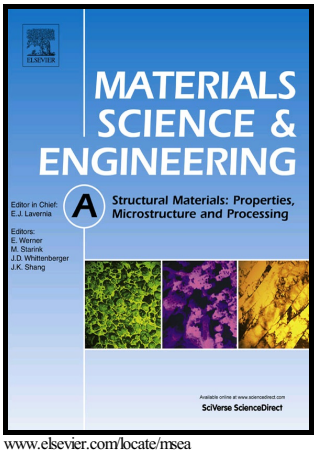

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Role of brittle sigma phase in cryogenic-temperature-strength improvement of non-equi-atomic Fe-rich VCrMnFeCoNi high entropy alloys

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Abstract

An equi-atomic single-fcc-phase CrMnFeCoNi high entropy alloy (HEA) shows much higher tensile properties at cryogenic temperature than at room temperature because of its fcc characteristics and abundant twinning at cryogenic temperature. In order to further improve the cryogenic-temperature tensile properties of single-fcc-phase HEAs, we propose non-equi-atomic Fe-rich VCrMnFeCoNi HEAs, and analyze the strengthening effects of the brittle intermetallic sigma (σ) phase. The σ phase is unintentionally obtained, but favorably shows a pronounced strengthening by its hardness and grain refinement effect due to grain-boundary pinning, which leads to high yield and tensile strengths of 0.76 GPa and 1.23 GPa, respectively, together with good ductility of 54%. This positive utilization of the σ phase is unexpected because its formation has been suppressed in typical HEAs. Our results demonstrate that the present Fe-rich VCrMnFeCoNi design and σ-phase strengthening has potential in high-strength HEA studies.

Keywords: high entropy alloy; thermodynamic calculation; cryogenic; mechanical property; sigma phase.

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