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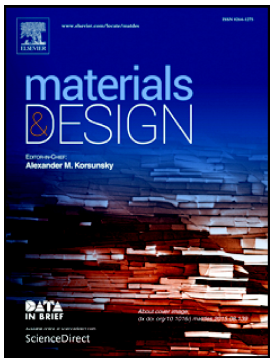


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# Strengthening Fe – $TiB_2$ based high modulus steels by precipitations

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**Abstract**

We systematically studied the microstructure, mechanical and physical properties of hyper-eutectic Fe – $TiB_2$ high modulus steels (20 vol. % $TiB_2$) with (Si, Mn, Ni) and Cu additions for the formation of G-phase and Cu precipitates during ageing treatments. Alloying with Si, Mn and Ni led predominantly to pronounced solid solution strengthening, reaching tensile strength (UTS) values up to 1100 MPa after quenching. While G-phase formation could be observed in aged materials, its preferential formation on grain boundaries significantly deteriorated ductility. Its effects on strength were partially balanced by a decrease of grain boundary density. Additions of 1 and 2 wt. % Cu, respectively, led to lower strength in the as quenched state, but also to significant strengthening via ageing. The peak aging conditions as well as the Cu particle structure and size are comparable to values reported for Cu strengthened interstitial free steels and Fe-Cu alloys. Both alloying additions slightly lowered the specific elastic modulus of the HMS, most pronounced for Cu addition with a drop of about 3 GPa $cm^3$ $g^{-1}$ per wt. % and also promoted embrittlement. Microstructure-property relationships and consequences for future alloy design, especially towards more ductile hypo-eutectic HMS, are outlined and discussed.

*Keywords*: steel; stiffness; density; G-phase; Cu precipitation