MATERIALS SCIENCE & ENGINEERING
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# Microstructures and Mechanical Properties of Novel FeNiMnAl Alloys

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abstract

Near-equiatomic FeNiMnAl alloys show a wide range of microstructures and mechanical properties, but have been little explored. Studies on three different types of microstructures in this alloy system will be outlined: 1) ultrafine microstructures (5-50 nm), present in $Fe_{30}Ni_{20}Mn_{20}Al_{30}$, $Fe_{25}Ni_{25}Mn_{20}Al_{30}$ and $Fe_{35}Ni_{15}Mn_{25}Al_{25}$, which consist of (Fe, Mn)-rich B2-ordered (ordered b.c.c.) and (Ni, Al)-rich $L2_1$-ordered (Heusler) phases, and in $Fe_{30}Ni_{20}Mn_{25}Al_{25}$, which consist of (Ni, Al)-rich B2 and (Fe, Mn)-rich b.c.c. phases, with the phases aligned along <100>; 2) fine microstructures (50-70 nm), present in $Fe_{30}Ni_{20}Mn_{30}Al_{20}$, $Fe_{25}Ni_{25}Mn_{30}Al_{20}$, and $Fe_{28}Ni_{18}Mn_{33}Al_{21}$, which consist of alternating (Fe, Mn)-rich f.c.c and (Ni, Al)-rich B2-ordered plates with an orientation relationship close to f.c.c.(002)//B2(002); f.c.c.(011)//B2(001); and 3) coarser (0.5-1.5 µm) lamellar microstructures observed in alloys with a lower aluminum content, such as $Fe_{30}Ni_{20}Mn_{35}Al_{15}$, that consist of alternating (Fe, Mn)-rich f.c.c and (Ni, Al)-rich B2-ordered phases with a Kurdjumov-Sachs orientation relationship between the phases. The microstructures and mechanical properties in these alloys have been determined as a function of annealing time, testing temperature and strain rate. Some unusual features that have been observed include: no change of hardness as the phase width increases in some of the B2/$L1_2$ alloys; a lower BDTT for coarser phase-sized $Fe_{30}Ni_{20}Mn_{20}Al_{30}$ than material with a finer phase size; a monotonic increase in elongation with increasing phase spacing in $Fe_{28}Ni_{18}Mn_{33}Al_{21}$; room temperature environmental embrittlement at slow strain rates in $Fe_{30}Ni_{20}Mn_{35}Al_{15}$, and a monotonic improvement in this embrittlement with increasing concentrations of Cr.

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