

Claims

1. A hydrogen storage alloy having the formula $Ti_xZr_yMn_zCr_u(VFe)_vM_w$, wherein
M is selected from one or more of V, Fe, Cu, Co, Mo, Al, La, Ni, Ce and Ho;
x is 0.6 – 1.1;
y is 0 - 0.4;
z is 0.9 - 1.6;
u is 0 – 1;
v is 0.01 – 0.6;
w is 0 – 0.4.
2. The hydrogen storage alloy according to claim 1, wherein v is 0.02 – 0.6.
3. The hydrogen storage alloy according to claim 1 or 2, wherein v is 0.05, 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.50, 0.55 or 0.60.
4. The hydrogen storage alloy according to any one of claims 1 to 3, wherein x is 0.9 – 1.1.
5. The hydrogen storage alloy according to any one of claims 1 to 4, wherein y is 0.1 – 0.4.
6. The hydrogen storage alloy according to any one of claims 1 to 5, wherein z is 1.0 – 1.6.
7. The hydrogen storage alloy according to any one of claims 1 to 6, wherein z is 1.0, 1.05, 1.1, 1.15, 1.2, 1.25, 1.3, 1.35, 1.4, 1.45, 1.5, 1.55 or 1.6.
8. The hydrogen storage alloy according to any one of claims 1 to 7, wherein u is 0, 0.1, 0.15, 0.18, 0.2, 0.3, 0.4, 0.5, 0.6, 0.75, 0.8 or 0.95.
9. The hydrogen storage alloy according to any one of claims 1 to 8, wherein w is 0, 0.02, 0.05, 0.06, 0.07, 0.08, 0.09, 0.1, 0.2 or 0.4.
10. The hydrogen storage alloy according to any one of claims 1 to 9, wherein the alloy is annealed at a temperature of from 900°C to 1200°C.
11. A hydrogen storage alloy selected from:
 $Ti_{1.1}CrMn(V_{0.85}Fe_{0.15})_{0.2}$, $Ti_{1.1}CrMn(V_{0.85}Fe_{0.15})_{0.4}$, $Ti_{1.1}CrMn(V_{0.85}Fe_{0.15})_{0.4}Zr_{0.2}$,
 $Ti_{1.1}CrMn(V_{0.85}Fe_{0.15})_{0.4}Zr_{0.3}$, $TiMn_{1.5}(V_{0.85}Fe_{0.15})_{0.2}$, $TiMn_{1.5}(V_{0.85}Fe_{0.15})_{0.4}$,
 $TiMn_{1.5}(V_{0.85}Fe_{0.15})_{0.4}Zr_{0.2}$, $TiMn_{1.5}(V_{0.85}Fe_{0.15})_{0.4}Zr_{0.3}$, $Ti_{1.1}CrMn(V_{0.85}Fe_{0.15})_{0.2}$,
 $Ti_{1.1}CrMn(V_{0.85}Fe_{0.15})_{0.3}$, $Ti_{1.1}CrMn(V_{0.85}Fe_{0.15})_{0.4}$, $Ti_{1.1}CrMn(V_{0.85}Fe_{0.15})_{0.5}$,
 $Ti_{1.1}Zr_{0.2}CrMn(V_{0.85}Fe_{0.15})_{0.4}$, $Ti_{1.1}Zr_{0.3}CrMn(V_{0.85}Fe_{0.15})_{0.4}$, $Ti_{1.1}Zr_{0.4}CrMn(V_{0.85}Fe_{0.15})_{0.4}$,
 $Ti_{1.1}CrMn(V_{0.85}Fe_{0.15})_{0.5}V_{0.1}$, $Ti_{1.1}CrMn(V_{0.85}Fe_{0.15})_{0.5}V_{0.2}$, $Ti_{1.1}CrMn(V_{0.85}Fe_{0.15})_{0.5}V_{0.4}$,
 $Ti_{1.1}CrMn(V_{0.85}Fe_{0.15})_{0.4}Fe_{0.05}$, $Ti_{1.1}CrMn(V_{0.85}Fe_{0.15})_{0.4}Fe_{0.1}$, $Ti_{1.1}CrMn(V_{0.85}Fe_{0.15})_{0.4}Fe_{0.2}$,
 $Ti_{1.1}Zr_{0.1}CrMn(V_{0.85}Fe_{0.15})_{0.4}Fe_{0.1}$, $Ti_{1.1}Zr_{0.2}CrMn(V_{0.85}Fe_{0.15})_{0.4}Fe_{0.2}$,
 $TiZr_{0.1}CrMn(V_{0.85}Fe_{0.15})_{0.4}Fe_{0.05}$, $TiZr_{0.1}CrMn(V_{0.85}Fe_{0.15})_{0.4}Fe_{0.1}$, $Ti_{1.1}CrMn(V_{0.85}Fe_{0.15})_{0.4-900}$,
 $Ti_{1.1}CrMn(V_{0.85}Fe_{0.15})_{0.4}Zr_{0.2}Fe_{0.2-900}$, $Ti_{1.1}Zr_{0.3}CrMn(V_{0.85}Fe_{0.15})_{0.4-900}$,
 $TiZr_{0.1}CrMn(V_{0.85}Fe_{0.15})_{0.4}Fe_{0.05}$, $TiZr_{0.1}CrMn(V_{0.85}Fe_{0.15})_{0.4}Fe_{0.06}$,
 $TiZr_{0.1}CrMn(V_{0.85}Fe_{0.15})_{0.4}Fe_{0.07}$, $TiZr_{0.1}CrMn(V_{0.85}Fe_{0.15})_{0.4}Fe_{0.09}$,

TiZr_{0.15}CrMn(V_{0.85}Fe_{0.15})_{0.4}Fe_{0.05}, TiZr_{0.2}CrMn(V_{0.85}Fe_{0.15})_{0.4}Fe_{0.05},
TiZr_{0.25}CrMn(V_{0.85}Fe_{0.15})_{0.4}Fe_{0.05}, (Ti_{0.65}Zr_{0.35})_{1.05}MnCr_{0.8}Fe_{0.2},
(Ti_{0.65}Zr_{0.35})_{1.05}MnCr_{0.75}(V_{0.85}Fe_{0.15})_{0.05}Fe_{0.2}, Ti_{0.9}Zr_{0.15}Mn_{1.6}Cr_{0.2}(V_{0.85}Fe_{0.15})_{0.25},
Ti_{0.9}Zr_{0.15}Mn_{1.6}Cr_{0.2}(V_{0.85}Fe_{0.15})_{0.3}, Ti_{0.9}Zr_{0.15}Mn_{1.6}Cr_{0.2}(V_{0.85}Fe_{0.15})_{0.35},
Ti_{0.9}Zr_{0.15}Mn_{1.6}Cr_{0.2}(V_{0.85}Fe_{0.15})_{0.4}, Ti_{0.9}Zr_{0.15}Mn_{1.6}Cr_{0.1}Co_{0.1}(V_{0.85}Fe_{0.15})_{0.3},
Ti_{0.9}Zr_{0.15}Mn_{1.6}Cr_{0.1}Fe_{0.1}(V_{0.85}Fe_{0.15})_{0.3}, Ti_{0.9}Zr_{0.15}Mn_{1.6}Cr_{0.1}Mo_{0.1}(V_{0.85}Fe_{0.15})_{0.3},
Ti_{0.9}Zr_{0.15}Mn_{1.5}Cr_{0.2}Co_{0.1}(V_{0.85}Fe_{0.15})_{0.3}, Ti_{0.9}Zr_{0.15}Mn_{1.4}Cr_{0.3}Co_{0.1}(V_{0.85}Fe_{0.15})_{0.3},
Ti_{0.9}Zr_{0.15}Mn_{1.3}Cr_{0.4}Co_{0.1}(V_{0.85}Fe_{0.15})_{0.3}, Ti_{0.9}Zr_{0.15}Mn_{1.2}Cr_{0.5}Co_{0.1}(V_{0.85}Fe_{0.15})_{0.3},
Ti_{0.9}Zr_{0.15}Mn_{1.1}Cr_{0.6}Co_{0.1}(V_{0.85}Fe_{0.15})_{0.3}, Ti_{0.9}Zr_{0.15}Mn_{1.6}Cr_{0.18}Mo_{0.02}(V_{0.85}Fe_{0.15})_{0.2},
Ti_{0.9}Zr_{0.15}Mn_{1.6}Cr_{0.15}Mo_{0.05}(V_{0.85}Fe_{0.15})_{0.2}, Ti_{0.9}Zr_{0.15}Mn_{1.6}Cr_{0.1}Mo_{0.1}(V_{0.85}Fe_{0.15})_{0.2},
Ti_{0.9}Zr_{0.15}Mn_{1.6}Cr_{0.15}Mo_{0.05}(V_{0.85}Fe_{0.15})_{0.4}, Ti_{0.9}Zr_{0.15}Mn_{1.6}Cr_{0.1}Mo_{0.1}(V_{0.85}Fe_{0.15})_{0.4},
Ti_{0.9}Zr_{0.15}Mn_{1.15}Cr_{0.5}Co_{0.1}Fe_{0.05}(V_{0.85}Fe_{0.15})_{0.3}, Ti_{0.9}Zr_{0.15}Mn_{1.1}Cr_{0.5}Co_{0.1}Fe_{0.1}(V_{0.85}Fe_{0.15})_{0.3},
Ti_{0.9}Zr_{0.15}Mn_{1.05}Cr_{0.5}Co_{0.1}Fe_{0.15}(V_{0.85}Fe_{0.15})_{0.3}, Ti_{0.9}Zr_{0.15}Mn_{1.1}Cr_{0.5}Co_{0.2}(V_{0.85}Fe_{0.15})_{0.3},
Ti_{0.9}Zr_{0.15}MnCr_{0.5}Co_{0.2}(V_{0.85}Fe_{0.15})_{0.4}, Ti_{0.9}Zr_{0.15}Mn_{0.9}Cr_{0.5}Co_{0.2}Mo_{0.1}(V_{0.85}Fe_{0.15})_{0.4},
Ti_{0.88}Zr_{0.17}Mn_{1.15}Cr_{0.5}Co_{0.1}Fe_{0.05}(V_{0.85}Fe_{0.15})_{0.3}, Ti_{0.9}Zr_{0.15}Mn_{1.18}Cr_{0.5}Co_{0.1}V_{0.02}(V_{0.85}Fe_{0.15})_{0.3},
TiZr_{0.1}Cr_{0.95}Mn(V_{0.85}Fe_{0.15})_{0.4}Fe_{0.05}Al_{0.05}, Ti_{0.9}Zr_{0.15}Mn_{1.15}Cr_{0.5}Co_{0.1}V_{0.05}(V_{0.85}Fe_{0.15})_{0.3},
Ti_{0.9}Zr_{0.15}Mn_{1.1}Cr_{0.6}Co_{0.1}(V_{0.85}Fe_{0.15})_{0.35}, Ti_{0.9}Zr_{0.15}Mn_{1.1}Cr_{0.6}Co_{0.1}(V_{0.85}Fe_{0.15})_{0.4},
Ti_{0.91}Zr_{0.14}Mn_{1.1}Cr_{0.6}Co_{0.1}(V_{0.85}Fe_{0.15})_{0.4}, Ti_{0.9}Zr_{0.15}Mn_{1.05}Cr_{0.6}Co_{0.1}Fe_{0.05}(V_{0.85}Fe_{0.15})_{0.3},
Ti_{0.9}Zr_{0.15}Mn_{0.95}Cr_{0.6}Co_{0.1}Fe_{0.05}(V_{0.85}Fe_{0.15})_{0.4}, Ti_{0.9}Zr_{0.15}Mn_{1.05}Cr_{0.6}Co_{0.1}Fe_{0.05}(V_{0.85}Fe_{0.15})_{0.4},
TiMn_{1.5}(V_{0.85}Fe_{0.15})_{0.2}, TiMn_{1.5}(V_{0.85}Fe_{0.15})_{0.3}, TiMn_{1.5}(V_{0.85}Fe_{0.15})_{0.35}, TiMn_{1.5}(V_{0.85}Fe_{0.15})_{0.4},
TiMn_{1.5}(V_{0.85}Fe_{0.15})_{0.5}, TiZr_{0.05}Mn_{1.5}(V_{0.85}Fe_{0.15})_{0.3}, TiZr_{0.1}Mn_{1.5}(V_{0.85}Fe_{0.15})_{0.3},
TiZr_{0.2}Mn_{1.5}(V_{0.85}Fe_{0.15})_{0.3}, TiMn_{1.5}(V_{0.85}Fe_{0.15})_{0.4} V_{0.1}, TiMn_{1.5}(V_{0.85}Fe_{0.15})_{0.4} V_{0.2},
TiMn_{1.5}(V_{0.85}Fe_{0.15})_{0.4} V_{0.4}, TiMn_{1.5}(V_{0.85}Fe_{0.15})_{0.4}Fe_{0.2}, TiMn_{1.5}(V_{0.85}Fe_{0.15})_{0.4}Fe_{0.1}, TiMn_{1.5-900},
TiMn_{1.5}(V_{0.85}Fe_{0.15})_{0.2-900}, TiMn_{1.5}(V_{0.85}Fe_{0.15})_{0.3-900}, TiMn_{1.5}(V_{0.85}Fe_{0.15})_{0.4-900},
TiMn_{1.5}(V_{0.85}Fe_{0.15})_{0.5-900}, TiMn_{1.5}(V_{0.85}Fe_{0.15})_{0.4Zr0.05-900}, TiMn_{1.5}(V_{0.85}Fe_{0.15}

12. The hydrogen storage alloy according to any one of claims 1 to 11, having a hydrogen storage capacity of 1.5 wt% H₂, or at least 1.6 wt% H₂, or at least 1.7 wt% H₂, at least 1.8 wt% H₂, or at least 1.9 wt% H₂, or at least 2.0 wt% H₂, or least 2.1 wt% H₂, or least 2.2 wt% H₂, or least 2.3 wt% H₂, or least 2.4 wt% H₂, or least 2.5 wt% H₂, or at least 2.6 wt% H₂.

or at least 2.7 wt.% H₂, or at least 2.8 wt.% H₂, or at least 2.9 wt.% H₂, or least 3 wt.% H₂, or least 3.25 wt.% H₂, or least 3.5 wt.% H₂, or least 3.75 wt.% H₂, or at least 4 wt.% H₂ at 30 bar.

13. The hydrogen storage alloy according to any one of claims 1 to 12, having a hydrogen storage capacity of at least 4.5 wt% H₂, or least 5 wt% H₂, or least 6 wt% H₂ at 100 bar.
14. The hydrogen storage alloy according to claim 12 or 13, wherein the temperature is 50 °C or less, 40 °C or less, 30 °C or less, 20 °C or less, or 10 °C or less.
15. The hydrogen storage alloy according to any one of claims 1 to 14 which is adapted to desorb at least 65%, or at least 75%, at least 80%, or at least 85%, or at least 90%, or at least 95% of the stored hydrogen at 30 bar.
16. The hydrogen storage alloy according to any one of claims 1 to 15, capable of a rate of uptake and release of hydrogen of at least about 0.5 g H₂/min, or at least about 0.75 g H₂/min, or at least about 1.0 g H₂/min, or at least about 1.25 g H₂/min, or at least about 1.4 g H₂/min.
17. The hydrogen storage alloy according to any one of claims 1 to 16, having a C14 Laves phase structure.
18. Use of an alloy according to any one of claims 1 to 17, for the storage and release of hydrogen.