Study on iron-rich $(Mn,Fe)_{1.95}(P,Si)$ magneto-caloric material

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Motivation

★ **Magneto-caloric effect,** couples the magnetic moments to the lattice, is defined as heating or cooling a magnetic material by exposing the material to a changing magnetic field.

★ **Applications:**

Magnetic Refrigeration:[1]
- High efficiency
- Environmentally friendly

Power Generation:[2]
- High efficiency
- Waste heat to power

★ **Fe_2P-based $(Mn,Fe)_2(P,Si)$ materials:**

Large magneto-caloric effect
Large working temperature range
Cheap materials

★ **Problems:**

Large thermal hysteresis
Impurity phase $(Mn,Fe)_3Si$

Experimental results

✓ Off-stoichiometric composition

✓ Ball-milling technology

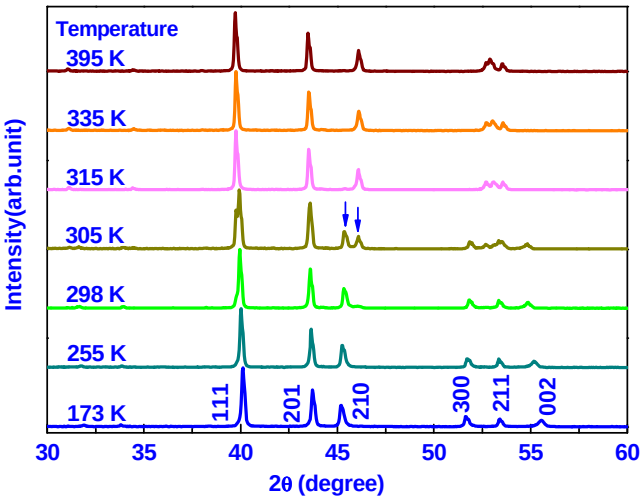

Fig.1 Temperature dependent X-ray diffraction patterns of $Mn_{0.75}Fe_{1.20}P_{0.66}Si_{0.34}$. The arrows indicate the coexistence of FM and PM phases.

- **Crystallizes in Fe_2P-type hex. structure**
- **No $(Mn,Fe)_3Si$ impurity phase is observed**

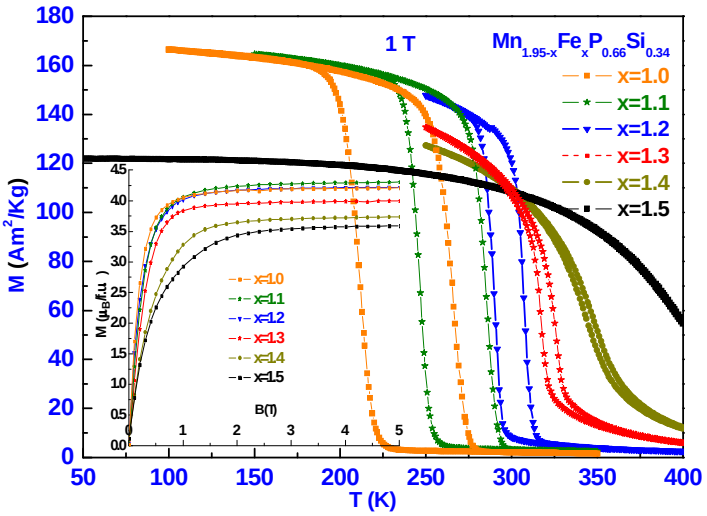

Fig. 2 Temperature dependence of the magnetization of $Mn_{1.95-x}Fe_xP_{0.66}Si_{0.34}$ measured in a field of 1 T. The insert shows the M-B curves measured at 5 K.

- **T_c can be adjusted by changing the Mn/Fe ratio**
- **ΔT_{hys} can be reduced by increasing Fe concentration**
- **Saturation magnetization at 5 K decreases with increasing Fe content**

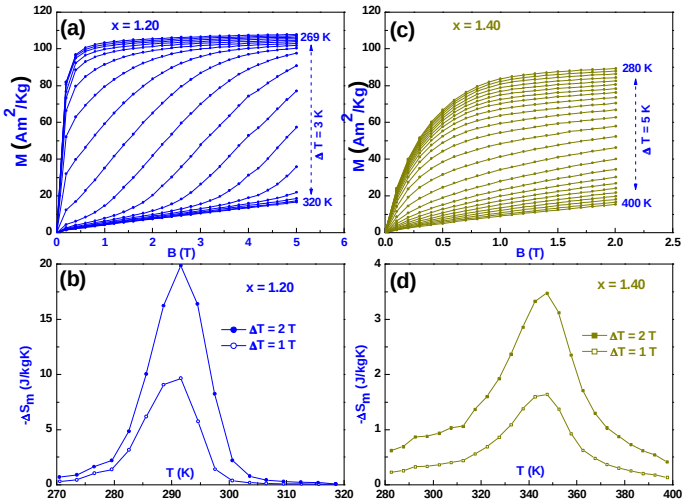

Fig .3 Magnetization curves of $Mn_{1.95-x}Fe_xP_{0.66}Si_{0.34}$ (x = 1.20 (a) and x = 1.40 (c)) in the vicinity of their Curie temperatures and the magnetic entropy changes (x = 1.20 (b) and x = 1.40 (d)) for different magnetic field changes.

- **Field induced transition is observed (x = 1.2), but is depressed with higher Fe content (x = 1.4)**
- **Large $-\Delta S_M$ is obtained on Iron-rich $(Mn,Fe)_{1.95}(P,Si)$ compounds, but the value is strongly reduced with further increasing Fe concentration**

References & Acknowledgements

[1] V. K. Pecharsky, K. A. Gschneidner Jr., Phys. Rev. Lett. 78, 4494 (1997).

[2] E. Brück, O. Tegus and K. Buschow, INTERMAG 2006, IEEE International, P85.

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Conclusions:

✚ **Single phase sample is obtained by using ball-milling technology.**

✚ **Thermal hysteresis decreases with increasing Fe concentration.**

✚ **For the iron-rich $(Mn,Fe)_{1.95}(P,Si)$ compounds, the Mn:Fe and/or P:Si ratio(s) still need to be optimized.**

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