Two Types of Ferrous Polycrystalline Shape-Memory Alloys Showing Superelasticity (FeNiCoAlTaB, FeMnAlNi)

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1. The Ways to Give Superelasticity to SMAs

- Shape Memory Effect・・・heating is required to return to original state (original shape).
- Superelasticity ・・・heating is *not* required to return to original state (elastic deformation).

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- Martensitic transformation should be thermoelastic to gain superelasticity.

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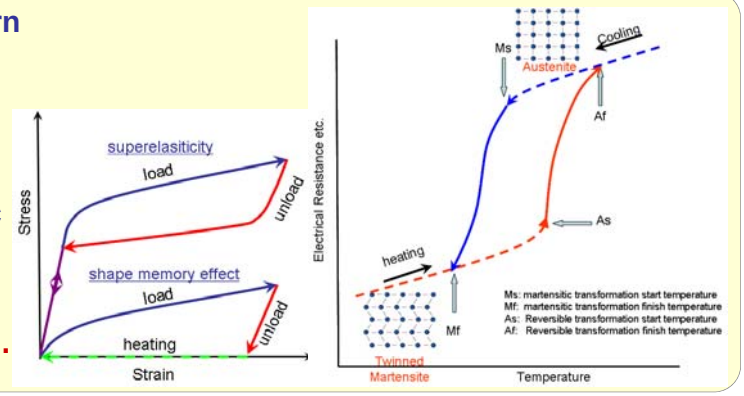
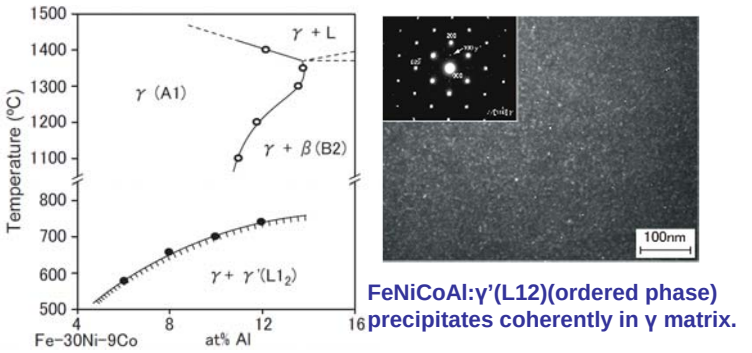
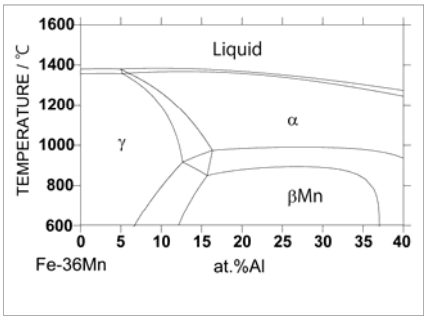
- Introduction of (partially) ordered phase is required.

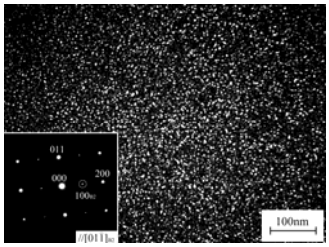


2. Alloy Design of FeNiCoAl and FeMnAl alloys with ordered precipitates



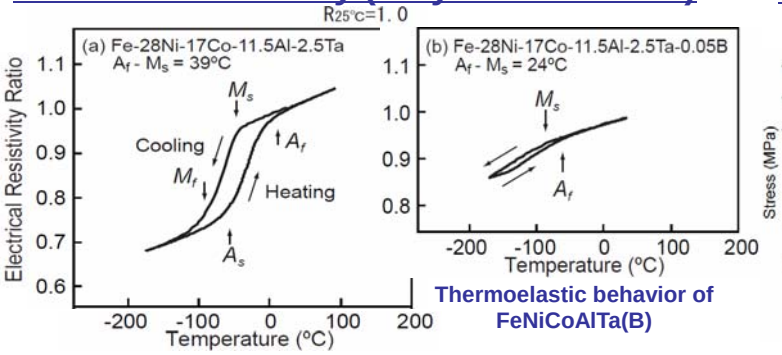
FeNiCoAl:γ'(L12)(ordered phase) precipitates coherently in γ matrix.





FeMnAlNi:B2(ordered phase) precipitates coherently in A2 matrix.

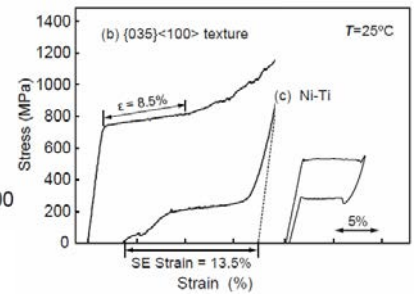
3. Thermoelasiticity (only for FeNiCoAl)



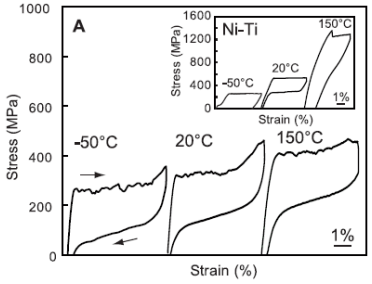
Thermoelastic behavior of FeNiCoAlTa(B)

4. Superelastic Properties

FeNiCoAlTaB

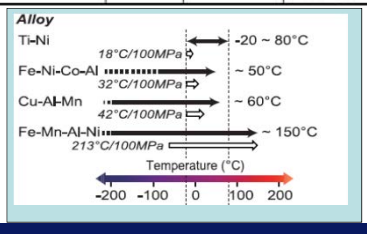


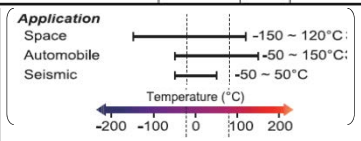
FeMnAlNi

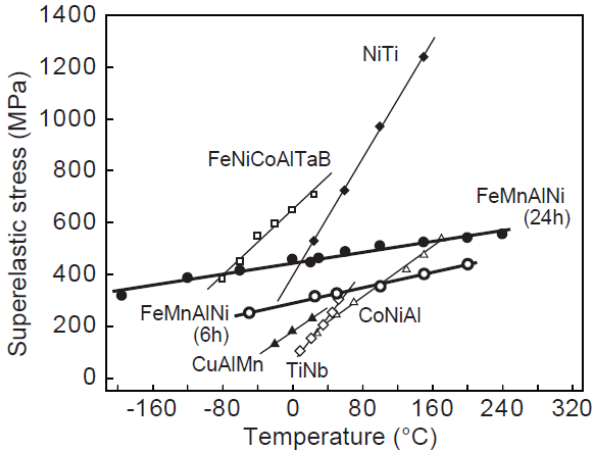


5. Comparison with Conventional Metal Alloys

Alloy system	Crystal structure		Chemical composition (at%)	ΔS (J mol⁻¹K⁻¹)	ε_{SE} (%)	$\frac{d\sigma_s}{dT}$ (MPa °C⁻¹)
	Parent	Martensite				
Fe-Mn-Al-Ni	BCC (A2+B2)	FCC	$Fe_{43.5}Mn_{34}Al_{15}Ni_{7.5}$	-0.43	5.2	0.53
Fe-Ni-Co-Al	FCC	BCT	$Fe_{40.95}Ni_{28}Co_{17}Al_{11.5}Ta_{2.5}B_{0.05}$	-2.95	13.5	3.1
Ti-Ni	B2	B19'	$Ti_{50}Ni_{50}$	-4.37	7.3	5.7
Ti-Ni-Cu	B2	B19	$Ti_{50}Ni_{40}Cu_{10}$	-2.92	3.2	8.4
Cu-Al-Ni	$D0_3$	6M	$Cu_{68.4}Al_{27.8}Ni_{3.8}$	-1.03	8.6†	1.5‡
	$D0_3$	2O		-1.20	4.7†	3.4‡
Cu-Zn-Al	$D0_3$	6M	$Cu_{67.9}Zn_{16.1}Al_{16}$	-1.45	8.5†	2.1‡
Cu-Al-Mn	$L2_1$	6M	$Cu_{71.9}Al_{16.6}Mn_{9.3}Ni_2B_{0.2}$	-1.15	7.5	2.4
Ni-Mn-Ga	$L2_1$	10M	$Ni_{52}Mn_{24.4}Ga_{23.6}$	-0.97	4.0†	3.5‡
Ni-Fe-Ga	$L2_1$	14M	$Ni_{51}Fe_{22}Ga_{27}$	-0.91	6.2†	1.9‡
Ti-Nb	BCC	Orthorhombic	$Ti_{74}Nb_{26}$	-1.30	2.3	4.4







6. Patent available for licensing

Patent No. :WO2007/055155, WO2011/046055 (JP, US, EP, CN, KR, CA)

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