$L_1 0$-FeNi alloy with addition composition

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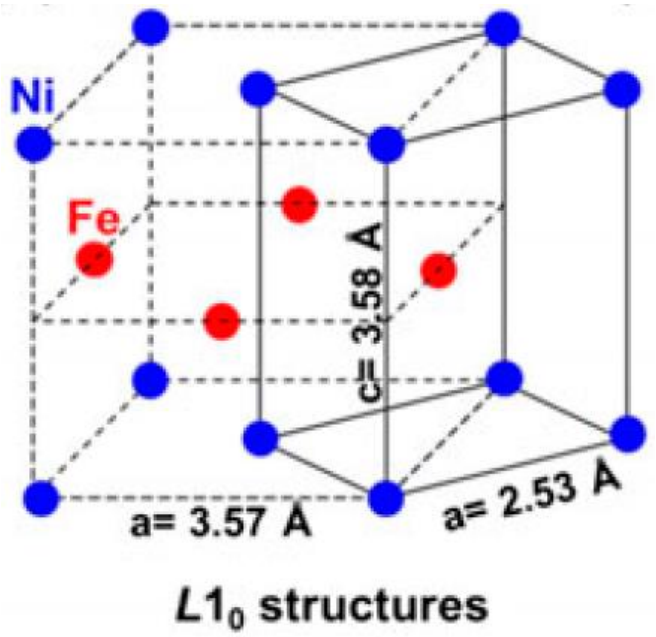
$L1_0$ structure FeNi



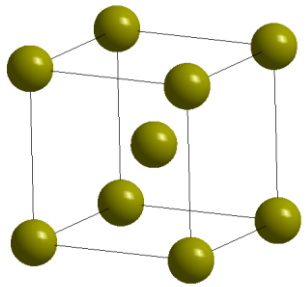
Tetragonal $L1_0$-ordered FeNi/tetrataenite/ γ’’, is a rare-earth-free magnetic compound.

saturation magnetization is 1.6μb/magnetic atom.

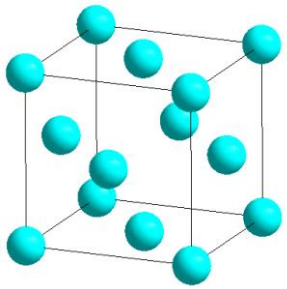
The compound naturally occurs in meteorites and requires millions of year to anneal in nature.

Theoretically magnetocrystalline anisotropy constant can be in the range K1=0.5–1MJ/m^3.

Phases of Fe-Ni



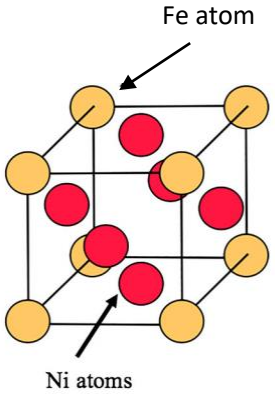
Fe : bcc



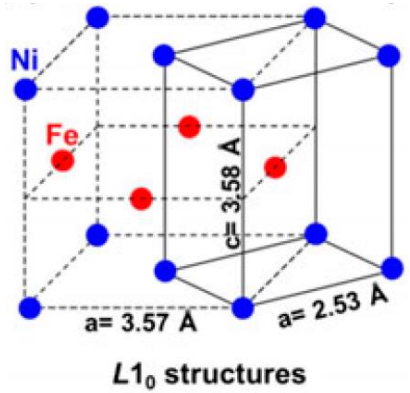
Ni: fcc

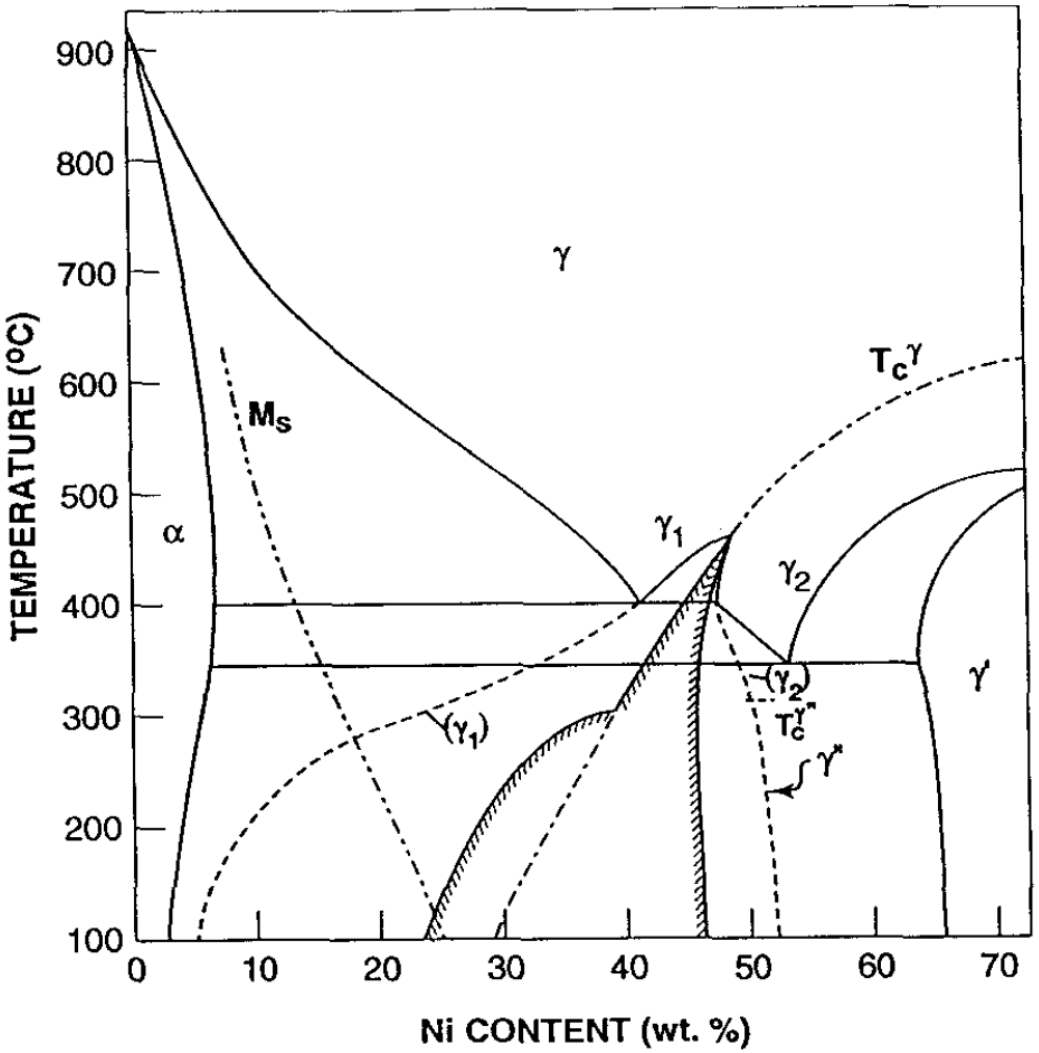
FeNi (any ratio) α phase : well mixed bcc
FeNi (any ratio) γ phase : well mixed fcc

FeNi3 γ’ phase : $L1_2$ structure



FeNi γ’’ phase : $L1_0$ structure





Phase diagram of Fe-Ni

C.-W. Yang, D. B. Williams, and J. I. Goldstein, J. Phase Equilib. 17(6), 522 (1996).

Table 1 Fe-Ni-S Alloys and Heat Treatments

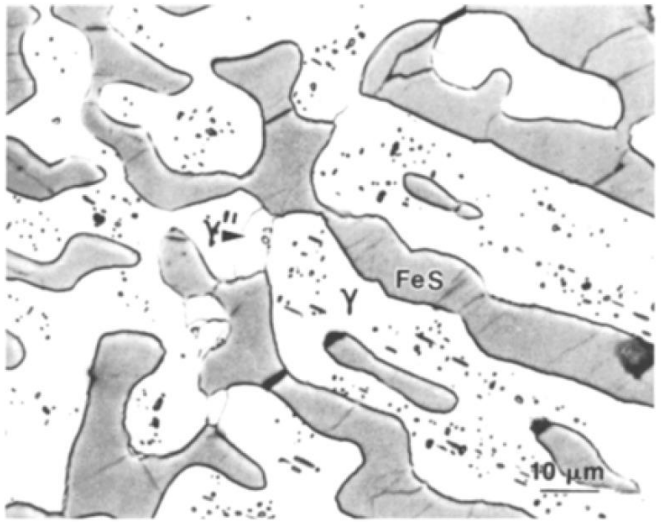
Temperature, °C	Alloy	Aging time, days	Structure
900	FeNi2.5S10	15	γ + FeS
	FeNi5S10	15	γ + FeS
	FeNi10S10	15	γ + FeS
	FeNi20S10	10	γ + FeS
800	FeNi2.5S10	42	α + γ + FeS
	FeNi5S10	42	γ + FeS
	FeNi10S10	42	γ + FeS
	FeNi20S10	42	γ + FeS
	FeNi30S10	42	γ + FeS
700	FeNi2.5S10	90	α + FeS
	FeNi5S10	90	α + γ + FeS
	FeNi10S10	90	γ + FeS
	FeNi20S10	90	γ + FeS
	FeNi30S10	110	γ + FeS
600	FeNi2.5S10	150	α + FeS
	FeNi5S10	150	α + γ + FeS
	FeNi10S10	150	α + γ + FeS
	FeNi30S10	150	γ + γ″ + FeS
500	FeNi2.5S10	150	α + FeS
	FeNi5S10	100	α + γ + FeS
	FeNi10S10	100	α + γ + FeS
	FeNi20S10	100	α + γ + FeS
	FeNi30S10	206	γ + γ″ + FeS
400	FeNi2.5S10	165	α + FeS
	FeNi5S10	165	α + FeS
	FeNi10S10	165	α + γ + FeS
	FeNi20S10	165	α + γ + FeS
	FeNi30S10	165	γ + γ′ + FeS
300	FeNi2.5S10	165	α + FeS
	FeNi5S10	165	α + FeS
	FeNi10S10	165	α + FeS + α_2(a)
	FeNi20S10	165	α + γ or γ″ + FeS
	FeNi30S10	165	α + $(Fe,Ni)_9S_8$ + FeS

sulfur has been found to positively affect the L10 phase formation

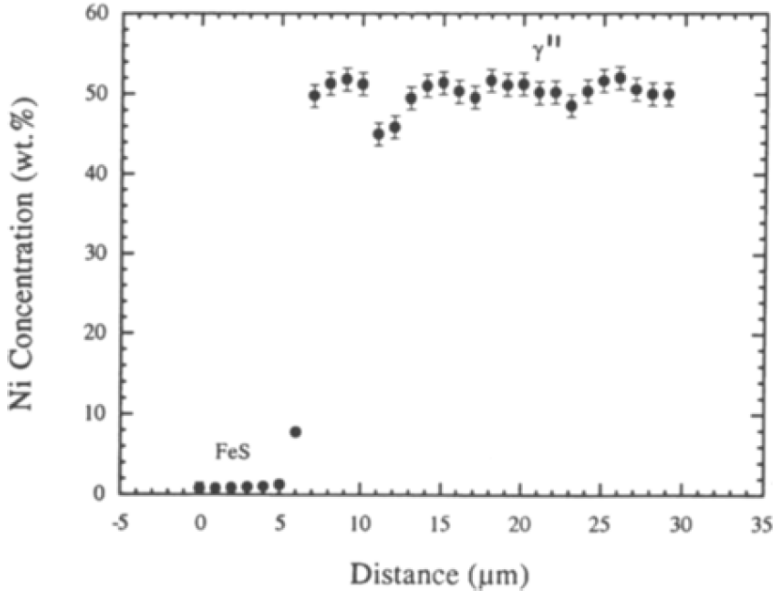
(2.5, 5,10, 20, and 30 wt.% Ni, 10 wt. % S, balance Fe)

Method: induction melting in alumina crucibles (Ar environment)

L. Ma, D. B. Williams, and J. I. Goldstein, J. Phase Equilib. 19, 299(1998)



Light optical microscope image for FeNi30S10 in 500C

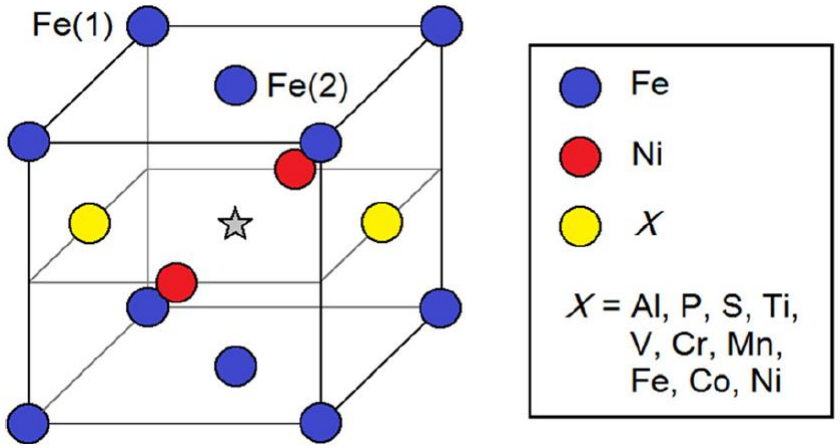


Ni composition profile across an FeS/ γ'' interface by electron probe microanalysis.

51.5±1.6 wt% in γ''

Transmission electron microscopy SAD :γ'' has fcc structure with a lattice parameter of 0.35 nm.

L. Ma, D. B. Williams, and J. I. Goldstein, J. Phase Equilib. 19, 299(1998)



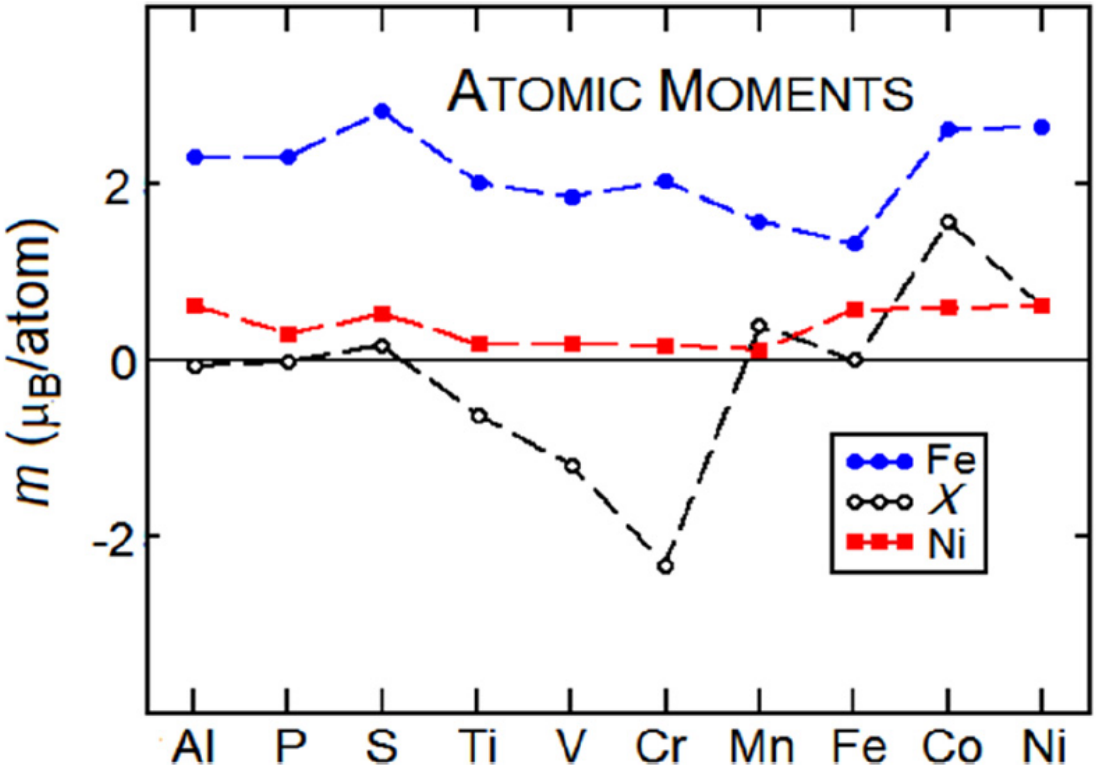
Basic $L1_0$ Fe_2NiX structures. The star in the center of the cell is the octahedral interstitial site in the Ni plane(no atom occupied).

TABLE I. Optimized lattice constants of the considered Fe_2XNi compounds.

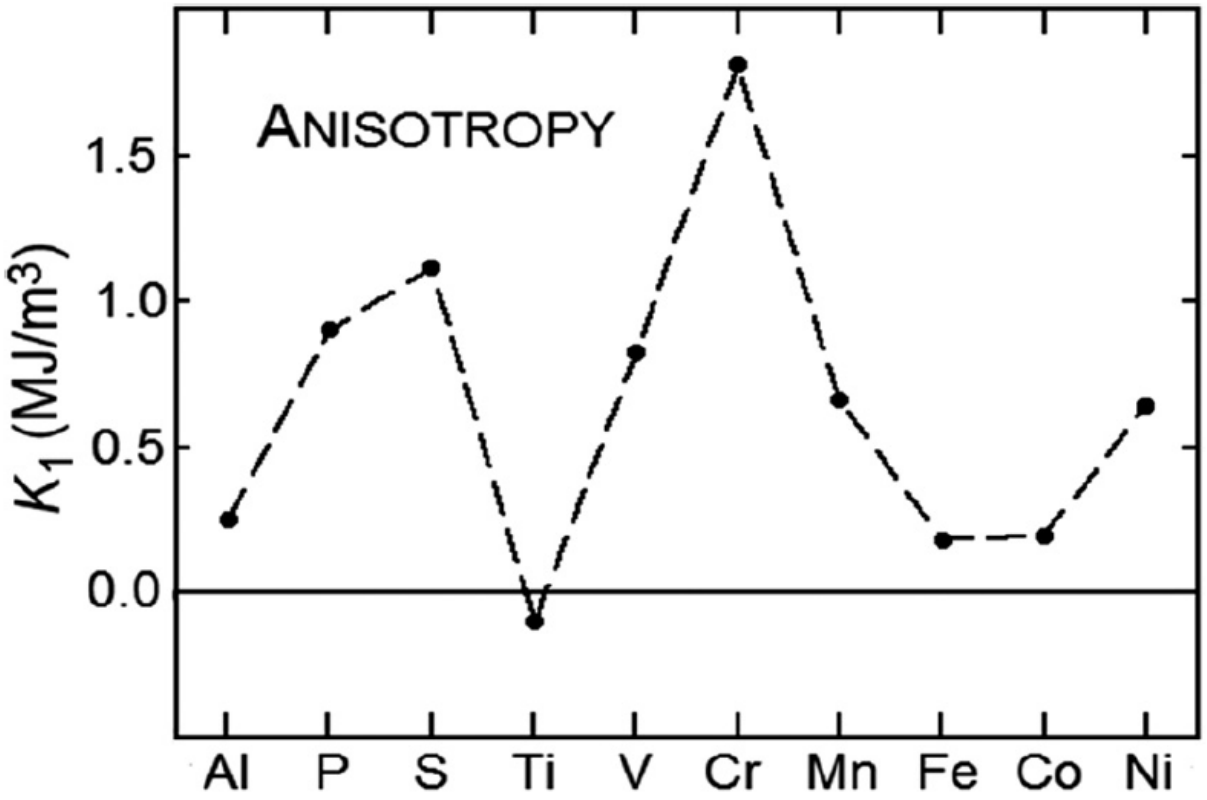
X	a (Å)	c (Å)
Al	3.494	3.864
P	3.457	3.754
S	3.537	3.834
Ti	3.571	3.797
V	3.577	3.559
Cr	3.561	3.571
Mn	3.504	3.506
Fe	3.594	3.594
Co	3.623	3.465
Ni	3.555	3.582

Optimized lattice constants of the considered Fe_2NiX compounds.

Manchanda, P., Skomski, R., Bordeaux, N., Lewis, L., & Kashyap, A. Journal of Applied Physics ***115****, 17A710 (2014)*



Atomic Moments in Fe_2NiX



Magnetocrystalline anisotropies in Fe_2NiX

Manchanda, P., Skomski, R., Bordeaux, N., Lewis, L., & Kashyap, A. *Journal of Applied Physics* ***115***, *17A710 (2014)*

Conclusion

sulfur has been found to positively affect the L10 phase formation

For Fe_2NiX alloy, x=S, Cr may be an option of permanent magnet

The magnetism of the modified alloys will require further experimental and theoretical work