Crystal structure and magnetic properties of FeNi

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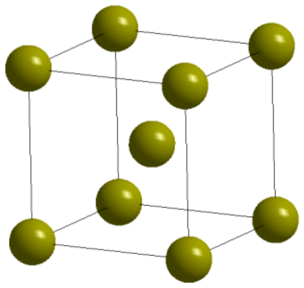
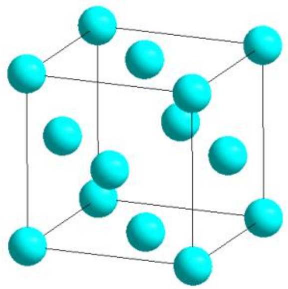
Phases of Fe-Ni



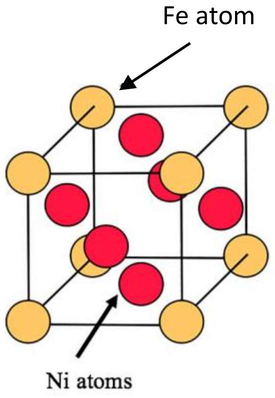
Fe : bcc



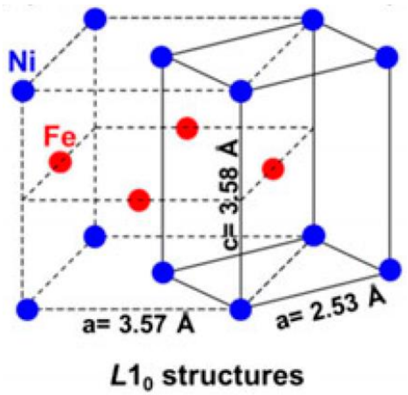
Ni: fcc

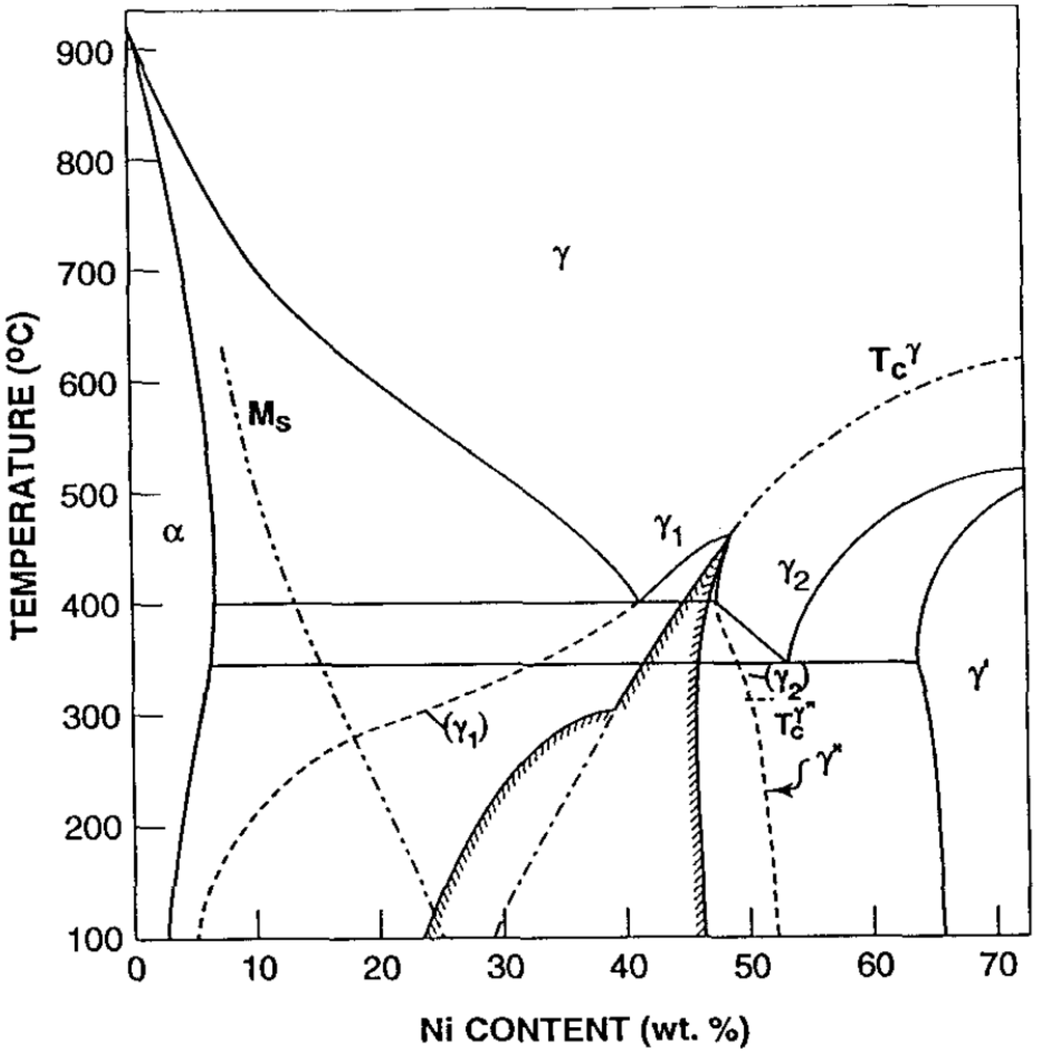
FeNi (any ratio) α phase : well mixed bcc
FeNi (any ratio) γ phase : well mixed fcc

FeNi3 γ' phase : $L1_2$ structure



FeNi γ'' phase : $L1_0$ structure

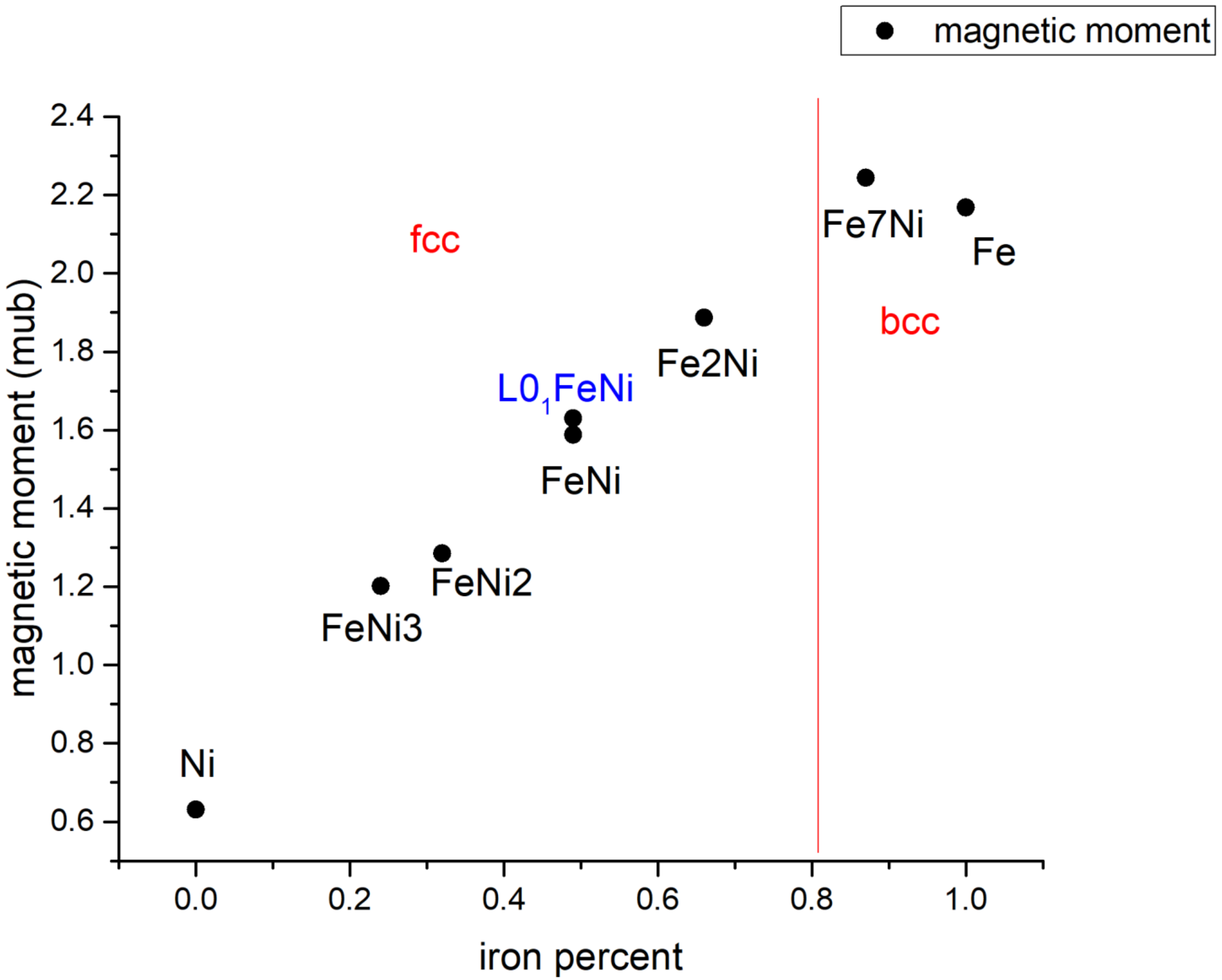




Phase diagram of Fe-Ni

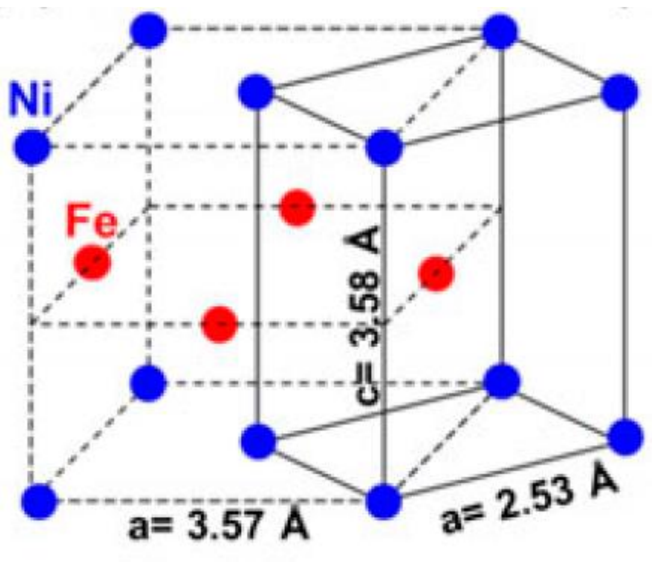
C.-W. Yang, D. B. Williams, and J. I. Goldstein, J. Phase Equilib. 17(6), 522 (1996).

Theoretical calculation of magnetic moment of Fe-Ni alloys



Mishin, Y., Mehl, M., & Papaconstantopoulos, D. Acta Materialia, 53(15), 4029-4041(2005).

L1$_0$ structure FeNi



$L1_0$ structures

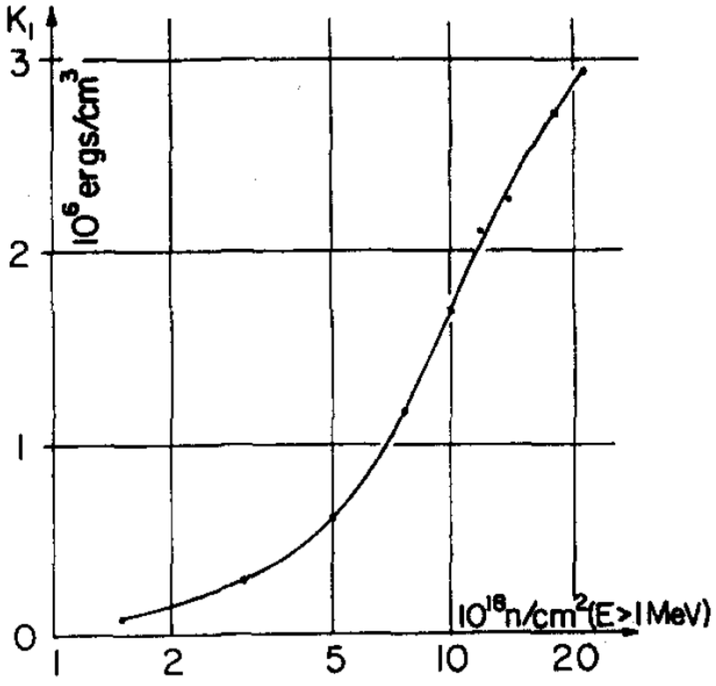
Tetragonal L1$_0$-ordered FeNi, also known as tetrataenite, is a rare-earth-free magnetic compound.

saturation magnetization is 1.6μb/magnetic atom.

The compound naturally occurs in meteorites and hard to acquire in lab.

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

FeNi (50-50) was first reported by Paulev in 1962



K_1 variation vs dose of neutrons during irradiation of an Fe-Ni single crystal with an applied magnetic field along the [100] axis.

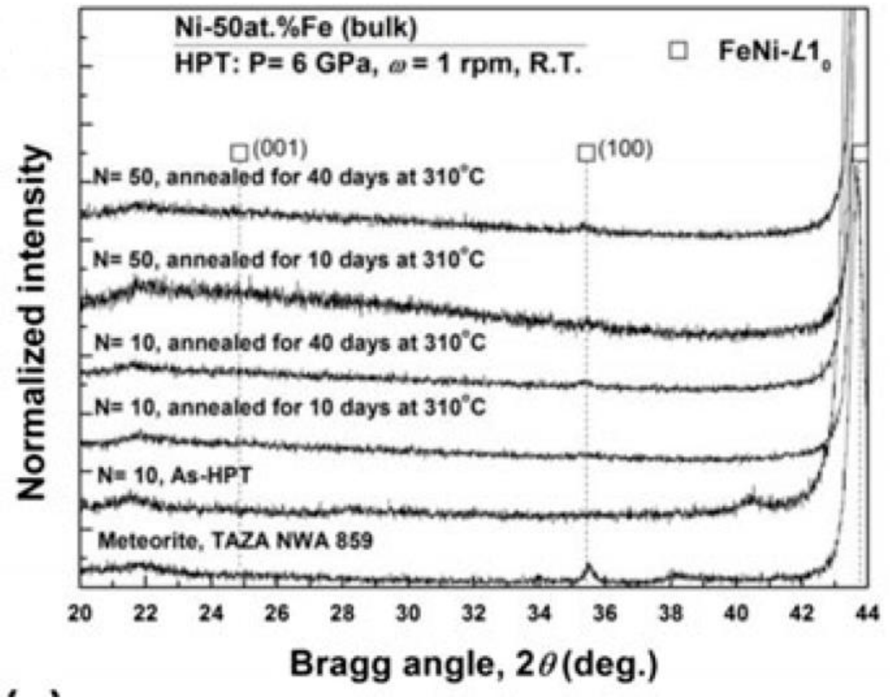
Acquire FeNi by bombarding a polycrystalline sample with neutrons

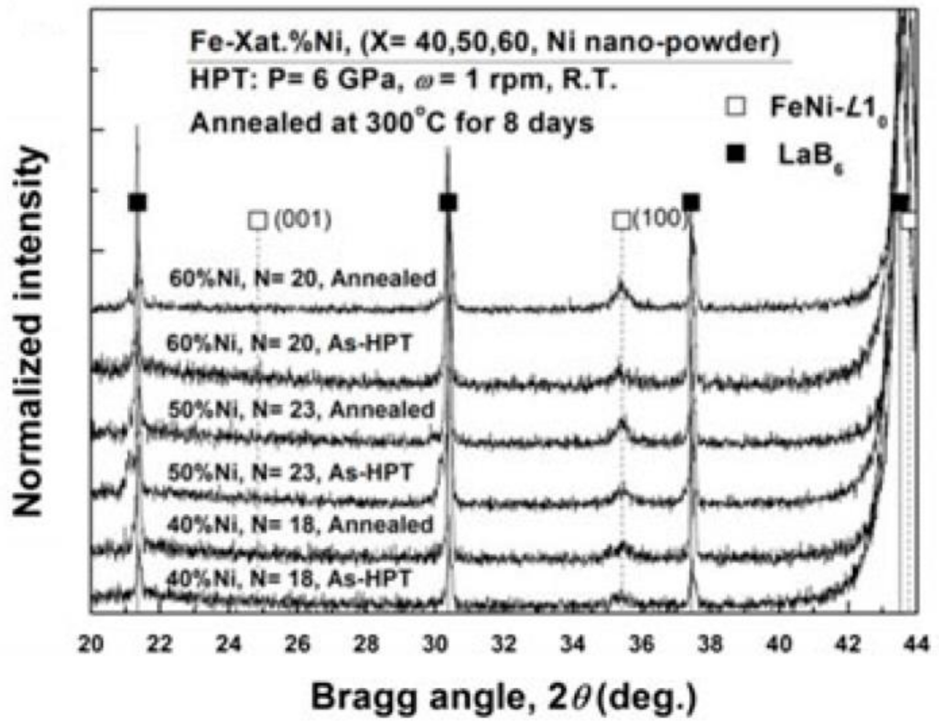
The formation of this ordered phase occurs with a very slow cooling rate (10^{-6} °C/year) because the $L1_0$-ordered phase is stable below temperatures as low as 320 °C.

L. Neel, J. Paulee, D. Dautreppe, and J. Laugier, C. R. Acad. Sc. 254, 965 ; J. Phys. Radium 23, 841 (1964).

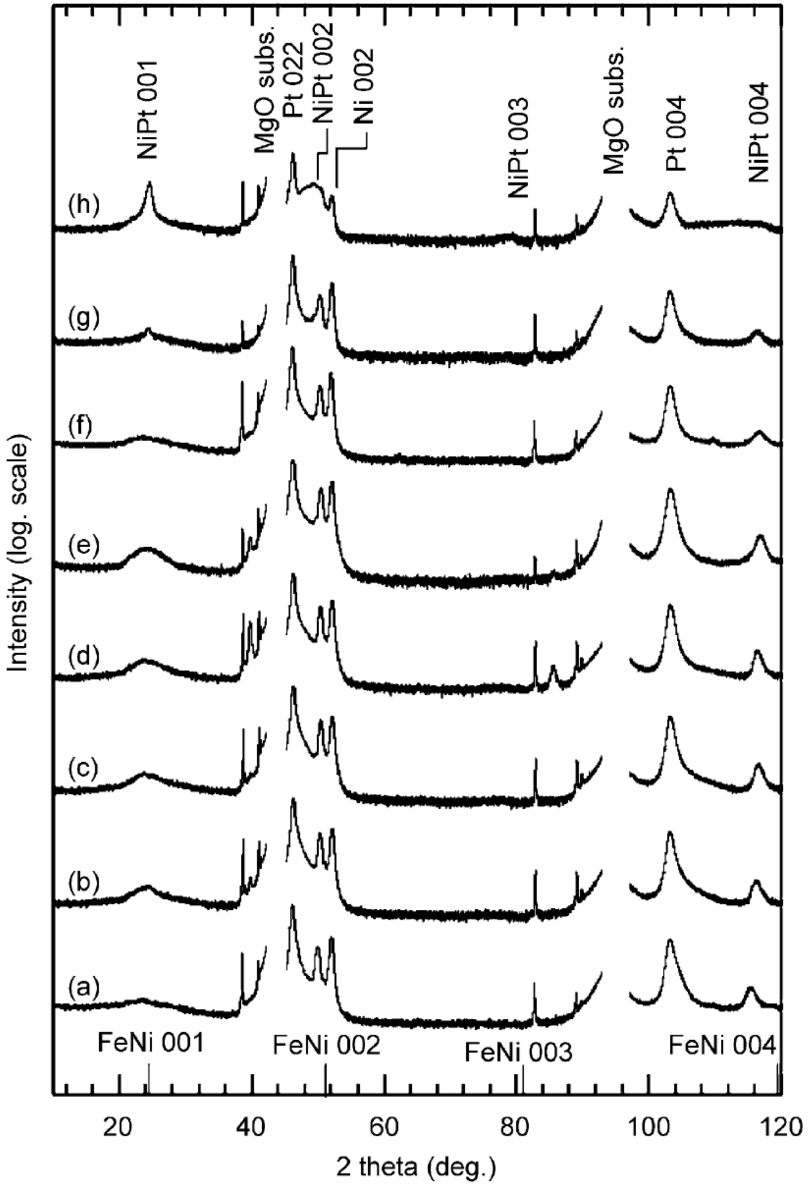
high-pressure torsion with 6Gpa

NWA 859 Taza meteorite



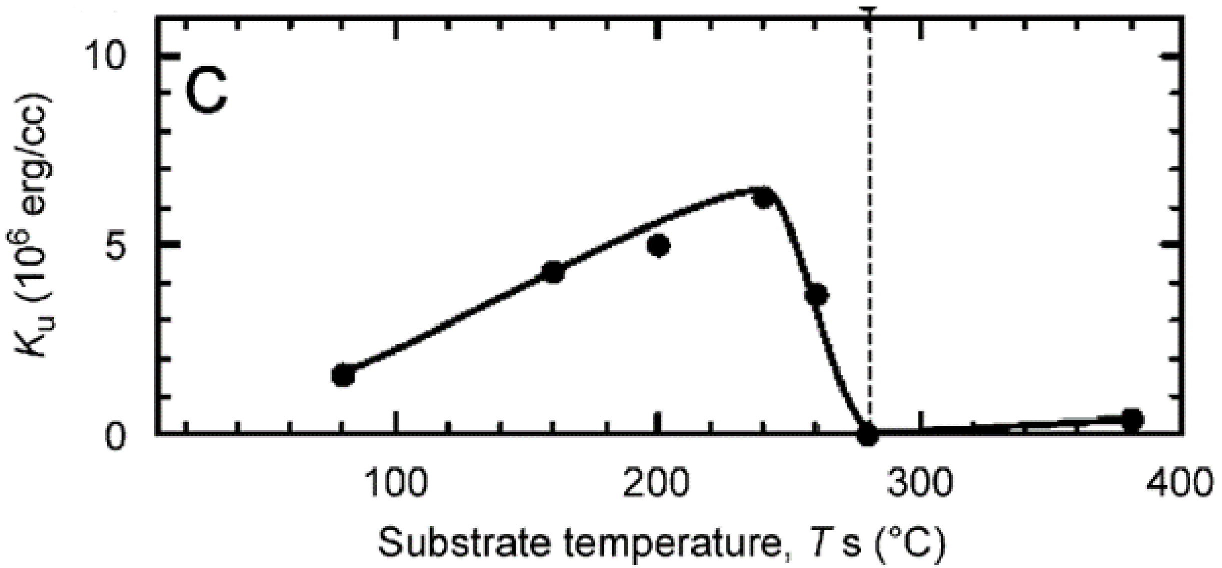


Lee, S., Edalati, K., Iwaoka, H., Horita, Z., Ohtsuki, T., Ohkochi, T., . . . Takanashi, K. Philosophical Magazine Letters, 94(10), 639-64(2014).



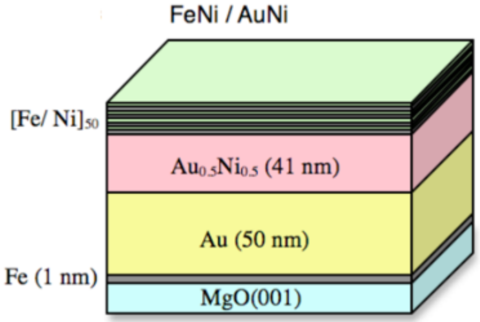
X-ray diffraction patterns for [Fe 1 Layer/Ni 1 Layer]50 films at various substrate temperatures 80C(a), 160 C (b), 200C (c), 240C (d), 260C (e), 280C (f), 380C (g), and 400C (h).

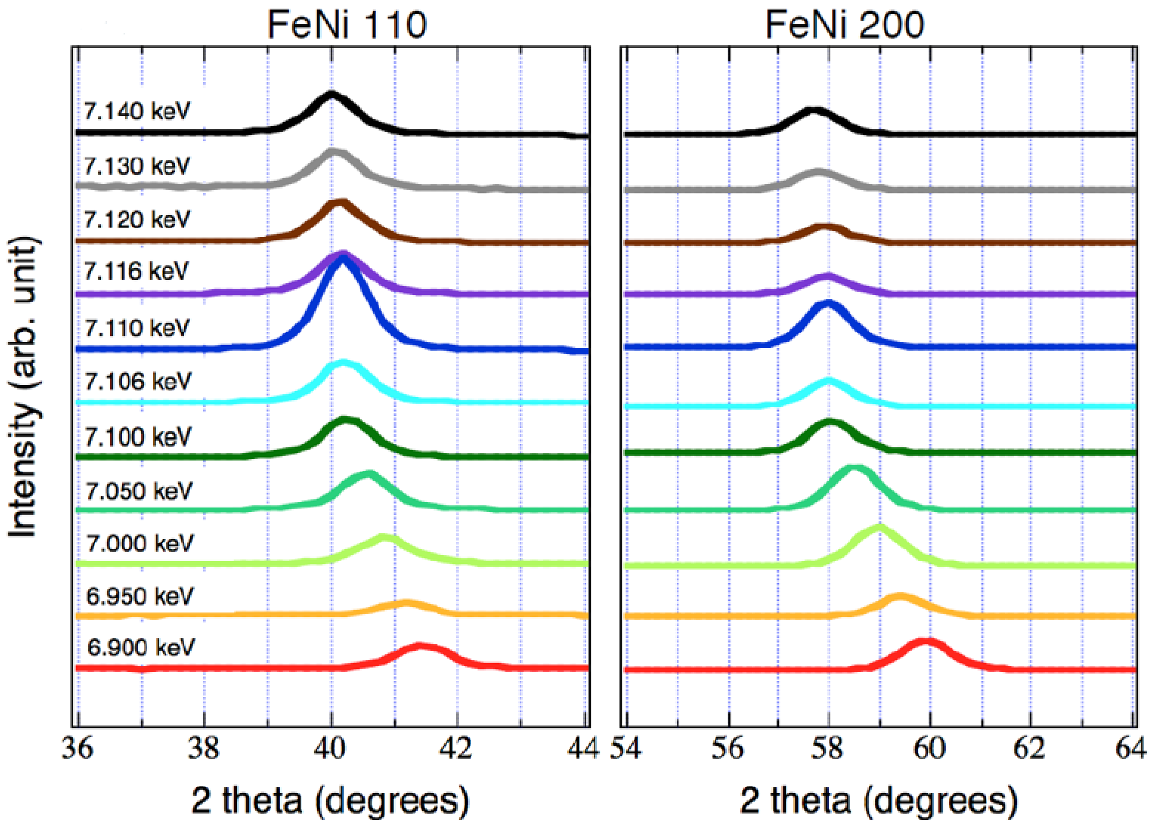
alternate monatomic layer deposition

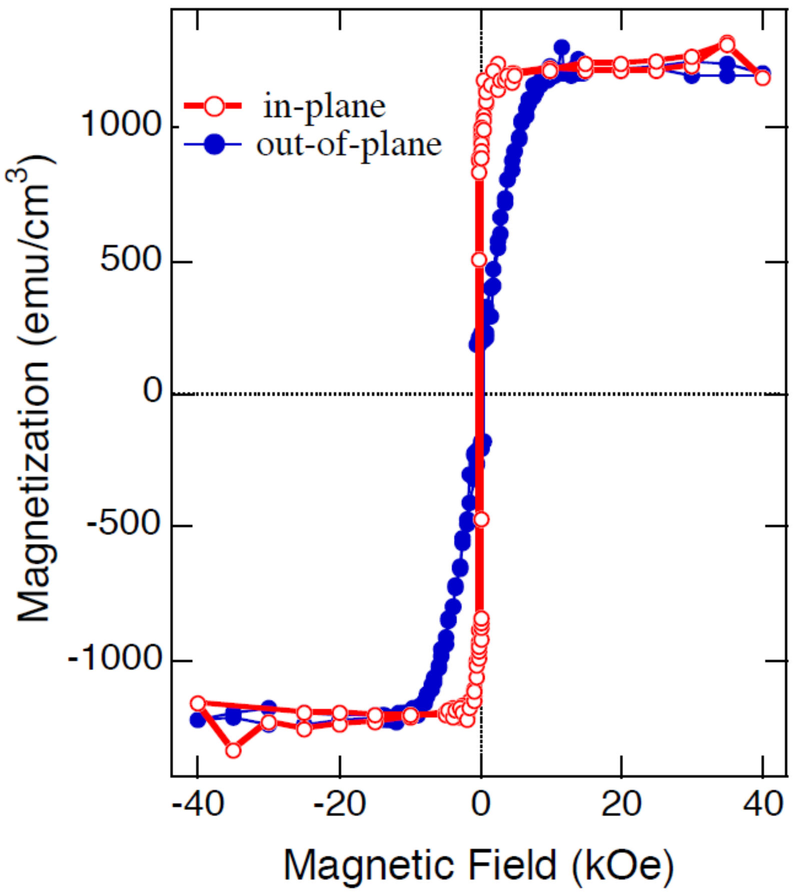


the uniaxial magnetic anisotropy K_u for (Fe 1 Layer/Ni 1 Layer)$_{50}$ films.

T. Shima, M. Okamura, S. Mitani, and K. Takanashi: J. Magn. Magn.Mater. 310, 2213 (2007).







Magnetization curve for FeNi. saturation magnetization is around 1.5μb/magnetic atom

X-ray diffraction patterns for FeNi on MgO(110) and MgO(100). Energy indicate the energy of X-ray.

Mizuguchi, M., Kojima, T., Kotsugi, M., Koganezawa, T., Osaka, K., & Takanashi, K. (2011). Journal of the Magnetics Society of Japan, 35(4), 370-373(2011).

Conclusion

1. $L1_0$ FeNi is a good rare earth free magnet with a high uniaxial anisotropy.
2. Because of the low stable temperature, a good way to grow FeNi is still unknown.