An introduction of $Nd_2Fe_{14}B$

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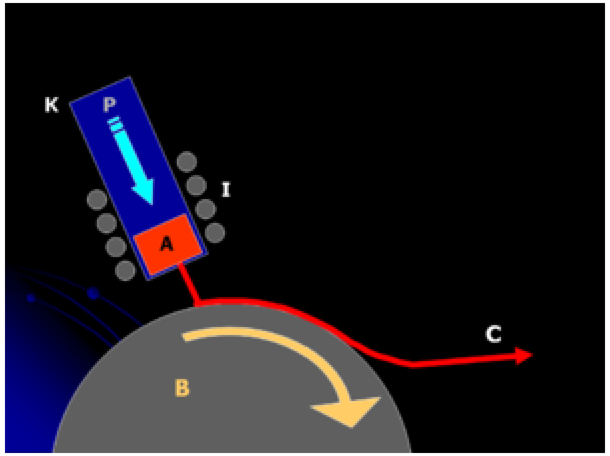
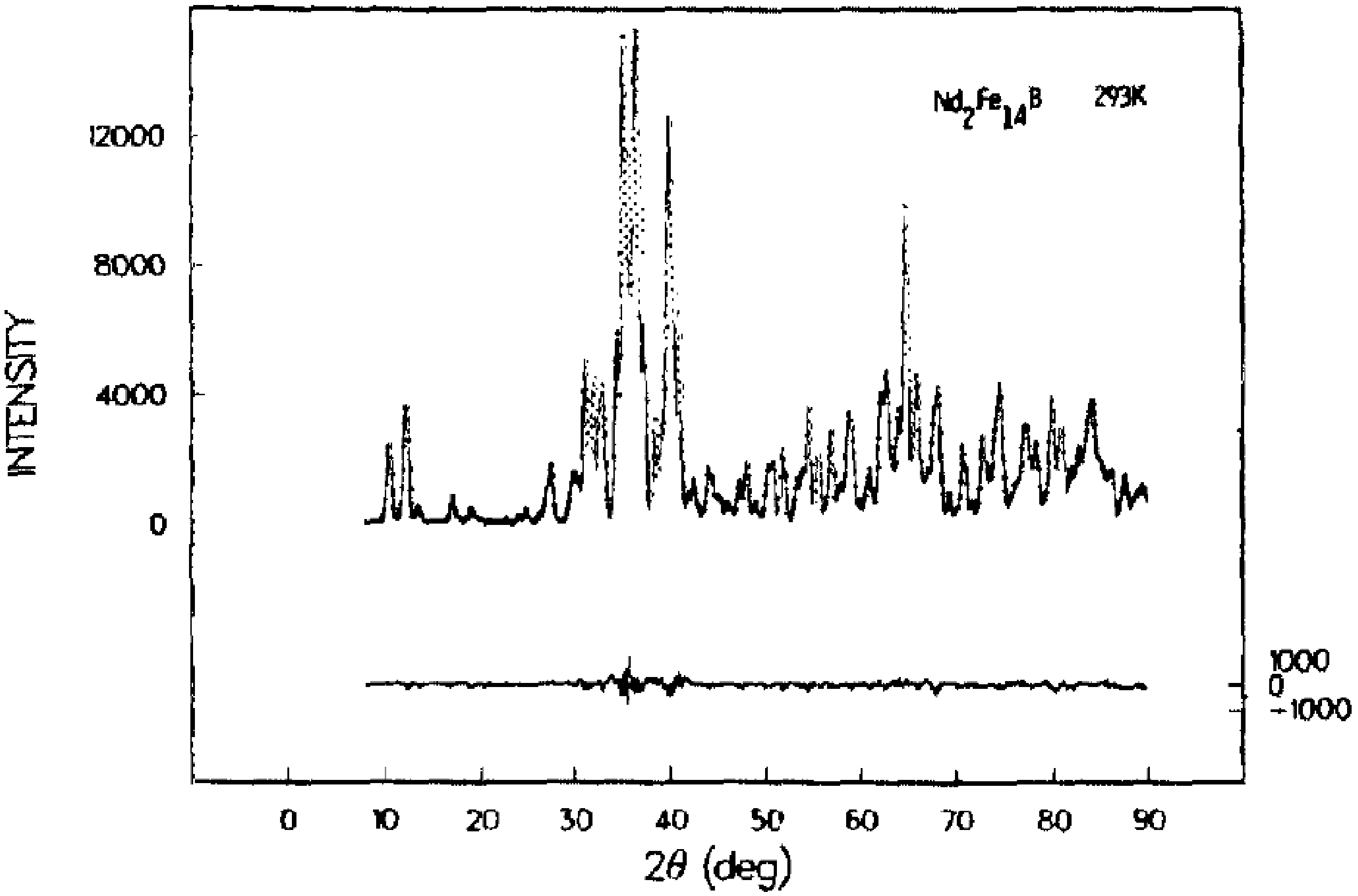
Neodymium magnet ($Nd_2Fe_{14}B$) is one of rare-earth-transition-metal (R-TM) systems.

Magnet	B_r (T)	H_{ci} (kA/m)	BH_{max} (kJ/m^3)	T_C (°C)
$Nd_2Fe_{14}B$	1.0–1.4	750–2000	200–440	310–400
$SmCo_5$	0.8–1.1	600–2000	120–200	720
Sm(Co, Fe, Cu, Zr)$_7$	0.9–1.15	450–1300	150–240	800

Method: melt-spinning or powder metallurgy/Sintering



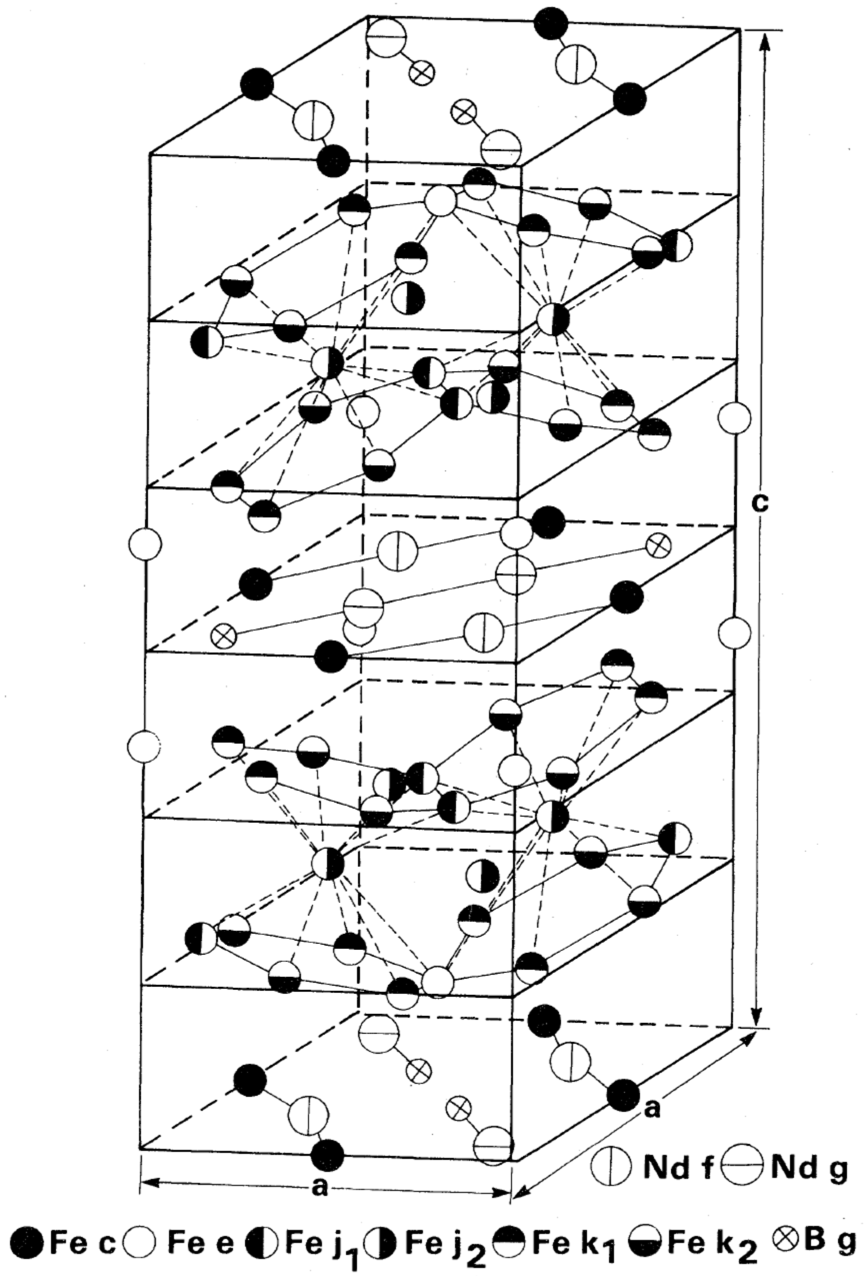
Performance:
powder metallurgy> melt-spinning



Neutron diffraction results for $Nd_2Fe_{14}B$ at 293K

The structure is gotten from the neutron diffraction data

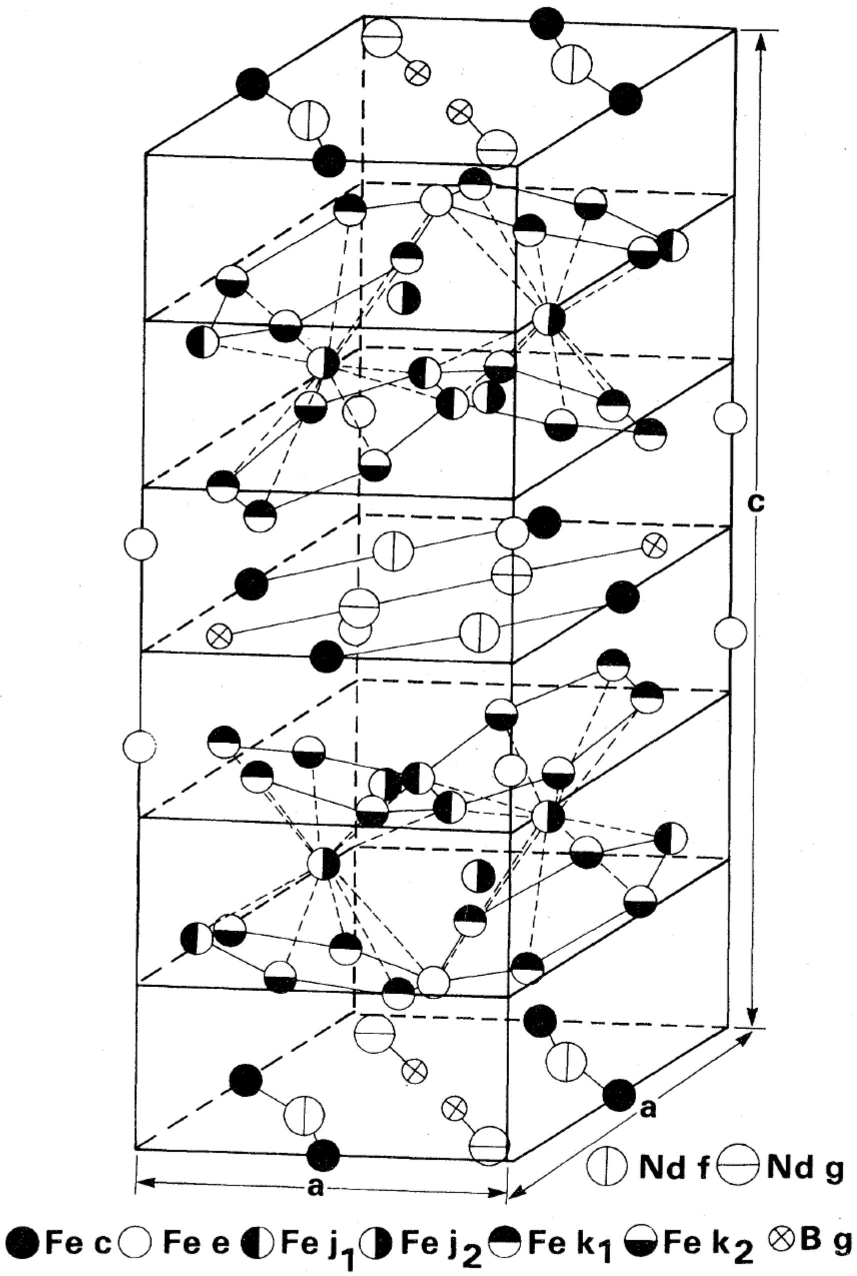
J.F. Herbst, J.J. Croat, F.E. Pinkerton, W.B. Yelon, Journal of Applied Physics ***57****, 4086 (1985)*

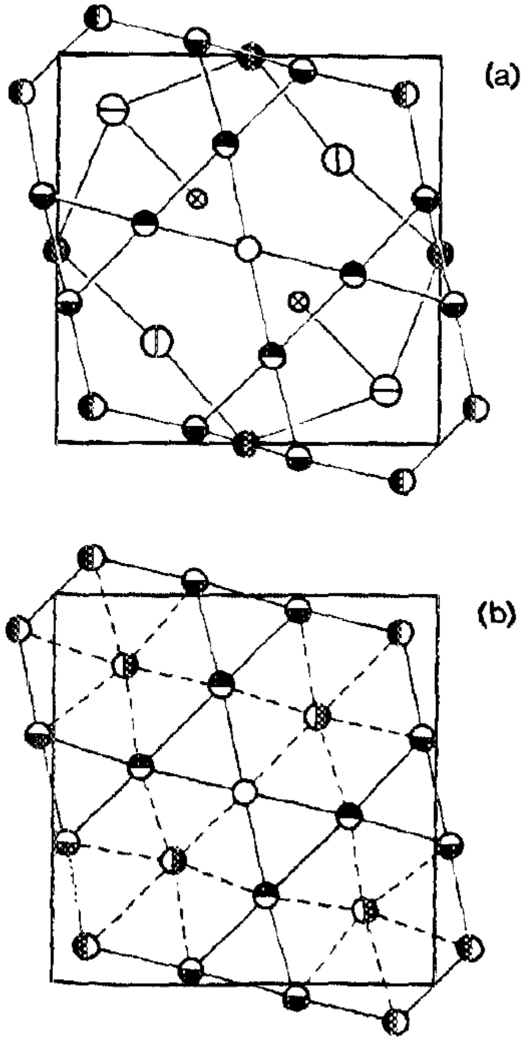


Unit cell of $Nd_2Fe_{14}B$
$P4_2/mnm$ space group
a =8.80 A, c =12.19 A

Atom	Site	Occupancy	*x*	*y*	*z*
Nd	*f*	4	0.266	0.266	0.0
Nd	*g*	4	0.139	−0.139	0.0
Fe	k_1	16	0.224	0.568	0.128
Fe	k_2	16	0.039	0.359	0.176
Fe	j_1	8	0.097	0.097	0.205
Fe	j_2	8	0.318	0.318	0.247
Fe	*e*	4	0.5	0.5	0.113
Fe	*c*	4	0.0	0.5	0.0
B	*g*	4	0.368	−0.368	0.0

J.F. Herbst, J.J. Croat, F.E. Pinkerton, W.B. Yelon, Phys. Rev. B 29 (1984) 4176





The moment arrangement is ferromagnetic, with all Nd and Fe moments parallel to the c axis of the tetragonal cell.

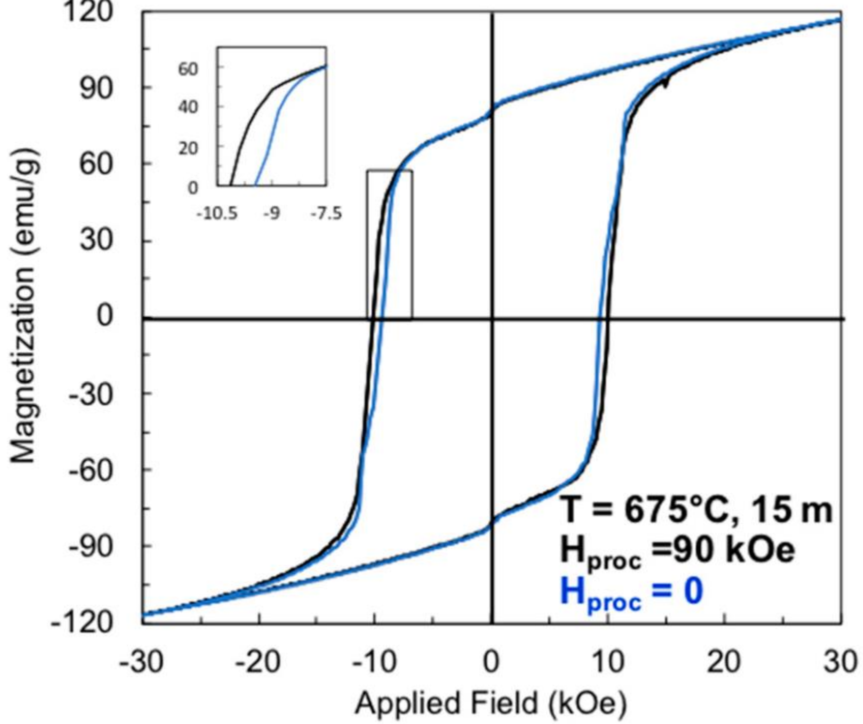
bulk moment of *35μB* per $Nd_2Fe_{14}B$ unit.

Ku~4.5MJ m^{-3}

(a)Projection of the basal plane and first Fe layer *(z~1/6)* in $Nd_2Fe_{14}B$.
(b) Projection of the first Fe layer and the Fe(j2) atoms *(z -1/4)* in $Nd_2Fe_{14}B$.

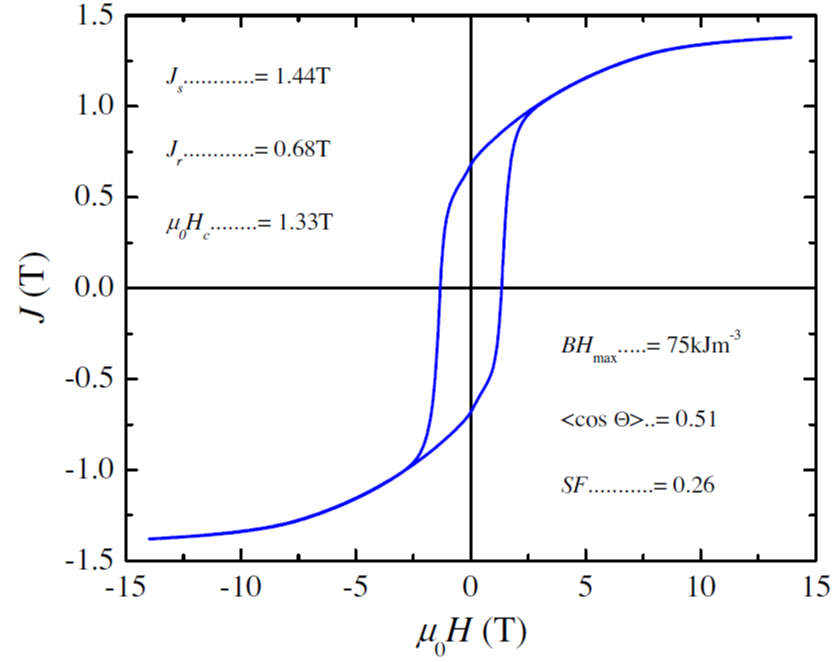
MH curve with vibrating sample magnetometer

melt-spinning sample



hysteresis curves of the fully crystallized ribbons at zero-field (blue) and in an applied field of 90 kOe (black)

Sintering sample



Hysteresis curve of the isotropic Nd–Fe–B sintered magnet (T = 300 K).

Theoretical coercivity field is 7.65T

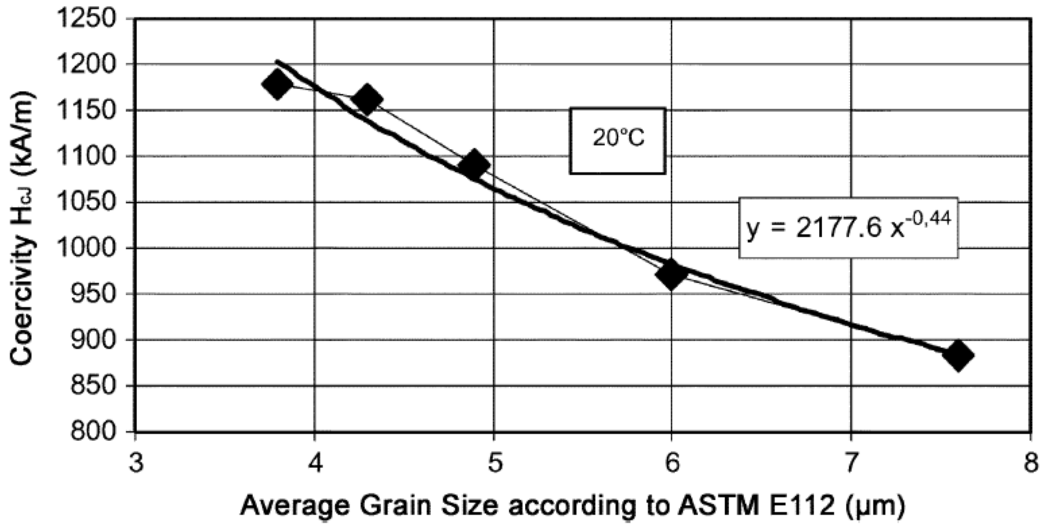
Kesler MS, Jensen BA, etc. Magnetochemistry. 2019; 5(1):16.

E. A. Perigo, E. Gilbert, A. Michels, Acta Mater. 2015, 87, 142.

Theoretical coercivity field is 7.65T

Two mean methods to increase the coercivity field

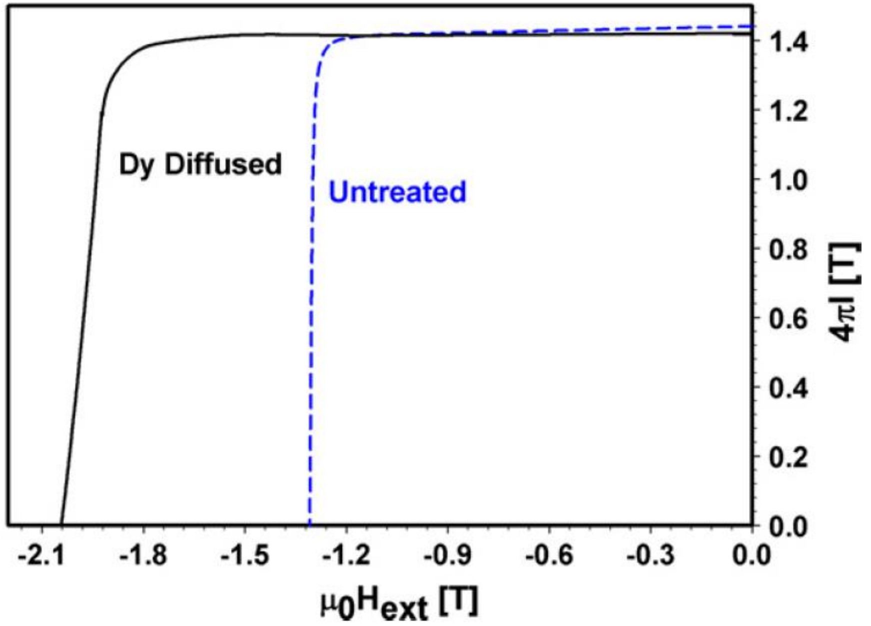
reduction of the grain size



Coercivity in dependence on the average grain size for room temperature.

K. Uestener, M. Katter, W. Rodewald, IEEE Trans. Magn. 42 (2006) 2897–2899.

grain boundary diffusion process



Demagnetization curves of untreated and GBDP samples

H. Sepehri-Amin, T. Ohkubo, K. Hono, Acta Mater. 61 (2013) 1982–1990.

Conclusion

$Nd_2Fe_{14}B$ has saturation magnetization (μ_0Ms = 1T~2T) and high magnetocrystalline anisotropy (Ku~4.5MJ m^{-3}).

anisotropic $Nd_2Fe_{14}B$ sintered magnets exhibit the highest energy product (higher than 474 kJ m^{-3}) of all the permanent magnetic materials.

The coercivity field is far from the theoretical value (7.65T) which is still under investigation.

The goal of our magnet program is to get a magnet comparable to $Nd_2Fe_{14}B$.