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Alloys and Compounds

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*Compounds of rare earth elements and Be,
Mg, Zn, Cd or Hg*

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Preface

The intrinsic magnetic properties of metals, alloys and metallic compounds have been systematically compiled in the various subvolumes 19A–F of the Landolt-Börnstein New Series Group III. Each subvolume is devoted to a separate and, from a point of view of the Periodic Table of the Elements, coherent group of substances. The amount of experimental data that became available since the publishing of each of these subvolumes in the years 1986 to 1994 gave us every reason to ask the various authors to consider the appropriateness of preparing supplements to their original work. As a result the first subvolume LB III/32A has been published in 1996, dealing with the magnetic properties of substances consisting of 3d, 4d and 5d elements, and of alloys between these elements, as well as alloys and compounds between 4d or 5d elements and main group elements. Meanwhile two other volumes have been published, LB III/32B and LB III/32C, both dedicated to alloys and compounds of 3d elements and main group elements.

The present volume LB III/32D is devoted to the magnetic properties of rare earth elements. Chapter 2.1 deals with the rare earth elements themselves, chapter 2.5 with their alloys and compounds with 4d or 5d elements, and chapter 2.7 with their alloys and compounds with the elements Be, Mg, Zn, Cd or Hg.

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The Editor

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List of symbols

Symbol	Unit	Quantity
a, b, c	nm, Å	lattice parameters
a_{us}	db cm ⁻¹	ultrasonic attenuation
B	Pa	bulk modulus
B	T, G	magnetic induction
B_{cr}	T, G	metamagnetic transition field
B_{r}	T, G	residual induction
C_p	J kg ⁻¹ K ⁻¹	heat capacity at constant pressure
C_V	J kg ⁻¹ K ⁻¹	heat capacity at constant volume
c	m s ⁻¹	sound velocity
c_{ij}	Pa	elastic constants
D	eV Å ² , THz Å ²	q^2 -expansion coefficient of the spinwave energy
E	J, erg, eV, Ry	energy
E	Pa	Young's modulus
E_a	J m ⁻³ , Pa	anisotropy energy
ΔE_a	J m ⁻³ , Pa	magnetoelastic anomaly
E_b	eV	binding energy
E_F	eV	Fermi energy
e/a		electrons per atom
f		magnetic form factor
f	T	de Haas – van Alphen frequency
G	Hz	Gilbert damping parameter
G	Pa	shear modulus
g		g -factor
H	J	enthalpy
H	A m ⁻¹ , Oe	magnetic field
H_A	A m ⁻¹ , Oe	magnetic anisotropy field
H_c	A m ⁻¹ , Oe	coercive field
H_{ext}	A m ⁻¹ , Oe	external magnetic field
$H_{\text{hf}}, H_{\text{hyp}}$	A m ⁻¹ , Oe	magnetic hyperfine field
h	J s	Planck's constant
"	J s	Planck's constant divided by 2π
h, k, l		Miller indices
I		intensity
I	A	electrical current
J		total angular momentum
J	eV	exchange constant
K		Knight shift
K	Å ⁻¹	wavevector
K	J m ⁻³ , erg cm ⁻³ , Pa	anisotropy constant
K_n	J m ⁻³ , erg cm ⁻³ , Pa	n^{th} -order magnetocrystalline anisotropy constants
k_B	J K ⁻¹	Boltzmann constant

Symbol	Unit	Quantity
L		orbital angular momentum
$\Delta l/l$		linear magnetostriction
M	A m^{-1} , T, G	magnetization
M_r	A m^{-1} , T, G	remanence
M_s	A m^{-1} , T, G	saturation magnetization
m_z	A m^{-1} , T, G	magnetization component
$N(E_F), N_F$	states $\text{eV}^{-1} \text{at}^{-1}$	density of states at the Fermi energy
n	states $\text{eV}^{-1} \text{at}^{-1}$	density of states
P		neutron polarization
$P(H)$		probability distribution
p	Pa, bar	pressure
\bar{p}	μ_B	atomic magnetic moment
\bar{P}	μ_B	average atomic magnetic moment
p_{at}	μ_B	magnetic moment per atom
p_{eff}	μ_B	effective paramagnetic moment
Q	J g^{-1}	heat of transformation
Q	mm s^{-1}	quadrupole shift
Q	V K^{-1}	thermoelectric power
Q, q	\AA^{-1}	wavevector
q_s/q_s		Rhodes – Wohlfarth ratio
R	$\text{J mol}^{-1} \text{K}^{-1}$	gas constant
R	Ω	electrical resistance
R	$\text{m}^3 \text{C}^{-1}$	Hall coefficient
R_0	$\text{m}^3 \text{C}^{-1}$	ordinary Hall coefficient
R_s	$\text{m}^3 \text{C}^{-1}$	extraordinary Hall coefficient
S		spin angular momentum
S	J K^{-1}	entropy
S	V K^{-1}	thermoelectric power
$S(K)$	barn $\text{sr}^{-1} \text{at}^{-1}$	elastic differential scattering function
T	K, °C	temperature
T_a	K	annealing temperature
T_C	K	Curie temperature
T_{cr}	K	critical temperature
T_f	K	spin-freezing temperature
T_g	K	spin-glass transition temperature
T_N	K	Néel temperature
T_R	K	spin reorientation temperature
T_t	K	transition temperature
T_1	s	longitudinal nuclear spin relaxation time
t	s	time
V	V	voltage
V_{zz}	V cm^{-2}	zz-component of electric field gradient
V	m^3	volume
v	m s^{-1}	velocity
x, y		composition
α	V K^{-1}	thermoelectric power
α	K^{-1}	linear thermal expansion coefficient
α_V	K^{-1}	volume thermal expansion coefficient
Γ	erg g^{-1}	torque

Symbol	Unit	Quantity
Γ	meV	linewidth, damping constant
γ	Hz G ⁻¹	gyromagnetic ratio
γ	J mol ⁻¹ K ⁻²	electronic specific heat coefficient
Δ	mm s ⁻¹	quadrupole splitting
δ	mm s ⁻¹	isomer shift
δ		incommensurability factor, $\delta = 1 - Qa/2\pi$
ε		linear strain
ζ		reduced wavevector
Θ	K	paramagnetic Curie temperature
Θ_D	K	Debye temperature
θ	deg	angle
κ	Å ⁻¹	inverse correlation length
κ	W m ⁻¹ K ⁻¹	thermal conductivity
λ		magnetostriction
λ	Å	wavelength
λ	s ⁻¹	relaxation rate
μ		relative permeability
μ_i		initial permeability
μ_0	T m A ⁻¹	permeability of the vacuum
ν	s ⁻¹ , Hz	frequency
ν_Q	mm s ⁻¹	quadrupole splitting
ρ	g cm ⁻³	density
ρ	cm ⁻²	dislocation density
ρ	Ω m	electrical resistivity
ρ_H	Ω m	Hall resistivity
$\Delta\rho/\rho$		magnetoresistance
σ	A m ² kg ⁻¹ , V s m kg ⁻¹ , G cm ³ g ⁻¹	bulk magnetic moment per unit of mass
σ	A m ² mol ⁻¹ , V s m mol ⁻¹ , G cm ³ mol ⁻¹	bulk magnetic moment per mole
σ	Pa	stress
σ	barn	cross section
τ	s	relaxation time
τ	s ⁻¹	relaxation rate
ϕ	deg	angle
χ_g	m ³ kg ⁻¹ , cm ³ g ⁻¹	magnetic susceptibility per unit of mass
χ_V		magnetic susceptibility per unit of volume
χ_m	m ³ mol ⁻¹ , cm ³ mol ⁻¹	magnetic susceptibility per mole
χ_P		Pauli susceptibility
χ'		real part of the complex magnetic susceptibility
χ''		imaginary part of the complex magnetic susceptibility
χ_1, χ_2		nonlinear magnetic susceptibility
Ω	sr	solid angle
ω		volume magnetostriction
ω	rad s ⁻¹	angular precession frequency
$\hbar\omega$	eV	excitation energy

List of abbreviations

a.u.	atomic unit	IRM	isothermal remanent magnetization
ac	alternating current	mag	magnetic
AF	antiferromagnetic	max	maximum
ASRO	atomic short range order	mc	multicritical
at	atom	ME	Mössbauer effect
av	average	min	minimum
bcc	body-centered cubic	μ SR	muon spin resonance
bct	body-centered tetragonal	NF	nonordered ferromagnetic
BPP	Bloembergen – Purcell – Pound	nl	nonlinear
CG	cluster glass	NMR	nuclear magnetic resonance
cl	cooling	orth	orthorhombic
cr	critical	P	paramagnetic
ct	centroid	PAC	perturbed angular correlation
cub	cubic	ppm	parts per million
dc	direct current	res	resonance
dHvA	de Haas – van Alphen	rf	radio frequency
dis	disordered	RT	room temperature
DOS	density of states	s	spontaneous; saturation
eff	effective	sc	single crystal
el	electronic	SCR	self-consistent renormalization
ESR	electron spin resonance	SDW	spin-density wave
ext	external	S-K	Sherrington – Kirpatrick
F	ferromagnetic	tetr	tetragonal
FC	field-cooled	trans	transmitted
fcc	face-centered cubic	TRM	thermoremanent magnetization
ftc	face-centered tetragonal	UPS	ultraviolet photoelectron spectroscopy
FWHM	full width at half maximum	us	ultrasonic
hcp	hexagonal close-packed	wt	weight
HF	high field	XPS	X-ray photoelectron spectroscopy
hf	hyperfine field	ZFC	zero-field cooled
inf	inflection		
int	internal		