

Landolt-Börnstein
Numerical Data and Functional Relationships in Science and Technology
New Series / Editor in Chief: O. Madelung

Group III: Crystal and Solid State Physics
Volume 19

Magnetic Properties of Metals

Subvolume i2
Magnetic Alloys for Technical Applications.
Hard Magnetic Alloys

Editor: H.P.J. Wijn

Contributors:
D. Bonnenberg, E. Burzo, K. Fukamichi, H.P. Kirchmayr,
T. Nakamichi, H.P.J. Wijn

Springer-Verlag
Berlin Heidelberg New York
London Paris Tokyo
Hong Kong Barcelona Budapest

Contents

List of symbols	XI
Definitions, units and conversion factors	XV
List of abbreviations	XVI
7 Magnetic alloys for technical applications	
7.1 Soft magnetic alloys, Invar and Elinvar alloys	see subvolume III/19i1
7.2 Hard magnetic alloys	1
7.2.1 Magnet alloys based on 3d elements (T. NAKAMICHI)	1
7.2.1.1 Introduction and list of abbreviations	1
7.2.1.1.1 Introduction	1
7.2.1.1.2 List of frequently used abbreviations	1
7.2.1.2 Magnet alloys with martensitic transformation	3
7.2.1.2.1 Fe-C base magnet alloys	3
7.2.1.2.1.1 Survey of the properties of Fe-C base magnet alloys	3
7.2.1.2.1.2 Permanent magnet properties of Fe-C, Fe-Cr-C and Fe-W-C alloys as dependent on the preparation technique	7
7.2.1.2.1.3 Permanent magnet properties of Fe-Al-C alloys as dependent on the preparation technique	10
7.2.1.2.1.4 Permanent magnet properties of Fe-Co-C alloys as dependent on the preparation technique	12
7.2.1.2.2 Fe-Ni and Fe-Mn base magnet alloys	13
7.2.1.2.2.1 Survey of the properties of Fe-Ni and Fe-Mn base magnet alloys	13
7.2.1.2.2.2 Permanent magnet properties of Fe-Ni base alloys as dependent on the preparation technique	16
7.2.1.2.2.3 Permanent magnet properties of Fe-Mn base alloys as dependent on the preparation technique	19
7.2.1.2.3 Fe-Co-V magnet alloys	22
7.2.1.2.3.1 Survey of the properties of Fe-Co-V magnet alloys	22
7.2.1.2.3.2 Permanent magnet properties of Fe-Co-V alloys as dependent on the preparation technique	26
7.2.1.3 fcc-type magnet alloys with a simple precipitation	30
7.2.1.3.1 Introduction	30
7.2.1.3.2 Co-Fe base magnet alloys with high Co content and Co-Fe-Ni alloys with a small amount of Nb	31
7.2.1.3.2.1 Survey of the properties of the magnet system	31
7.2.1.3.2.2 Permanent magnet properties of the alloy system as dependent on the preparation technique	34
7.2.1.4 bcc-type magnet alloys with a simple precipitation (Fe-Co-Mo and Fe-Co-W alloys)	45
7.2.1.5 bcc-type magnet alloys with spinodal decomposition	49
7.2.1.5.1 General introduction	49
7.2.1.5.2 Fe-Ni-Al base magnet alloys	50
7.2.1.5.2.1 Introduction	50
7.2.1.5.2.2 Fe-Ni-Al alloy system	55
7.2.1.5.2.3 Fe-(5...18) wt % Co-Ni-Al-Cu alloy system	60
7.2.1.5.2.4 Fe-24% wt % Co-Ni-Al-Cu alloy system	62
7.2.1.5.2.5 Fe-(30...40) wt % Co-Ni-Al-Ti-Cu alloy system	77
7.2.1.5.3 Fe-Cr-Co base magnet alloys	89
7.2.1.5.3.1 Introduction	89
7.2.1.5.3.2 Fe-Cr-(0...5) wt % Co alloy system	90
7.2.1.5.3.3 Fe-Cr-(10...15) wt % Co alloy system	95
7.2.1.5.3.4 Fe-Cr-(23...25) wt % Co alloy system	106
7.2.1.5.4 Fe-Mo-Ni base magnet alloys	108
7.2.1.6 fcc-type magnet alloys with spinodal decomposition (Cu-Ni-Co and Cu-Ni-Fe alloys)	113
7.2.1.6.1 Introduction	113

7.2.1.6.2	Permanent magnet properties of Cu-Ni-Co alloys as dependent on the preparation technique	119
7.2.1.6.3	Permanent magnet properties of Cu-Ni-Fe alloys as dependent on the preparation technique	124
7.2.1.7	Magnet alloys with order transformation (Co-Pt and Fe-Pt alloys)	130
7.2.1.7.1	Introduction	130
7.2.1.7.2	Permanent magnet properties of Co-Pt alloys as dependent on the preparation technique	134
7.2.1.7.3	Permanent magnet properties of Fe-Pt alloys as dependent on the preparation technique	136
7.2.1.8	Intermediate-phase magnet alloys (MnAl and MnAl (C) alloys)	139
7.2.1.8.1	Introduction	139
7.2.1.8.2	Permanent magnet properties of MnAl and MnAl (C) alloys as dependent on the preparation technique	143
7.2.1.9	Magnet alloys of the intermetallic compound MnBi	148
7.2.1.10	Fe-Cu magnet alloys	156
7.2.1.11	References for 7.2.1	161
7.2.2	Rare earth - 3d magnet alloys (D. BONNENBERG, H.P.J. WIJN)	166
7.2.2.1	Introduction	166
7.2.2.2	Sm-Co-magnet alloys	166
7.2.2.3	Sm-Co-Fe- (M) magnet alloys, M = Cr, Mn	174
7.2.2.4	Sm-Co-Cu magnet alloys	176
7.2.2.5	Sm-Co-Cu-Fe- (M) magnet alloys, M = Ti, Zr, Mn, Ni, Hf	181
7.2.2.6	(Sm)-R-Co-Cu- (Fe) magnet alloys (R = rare earth element)	189
7.2.2.7	References for 7.2.2	195
7.2.3	Nd ₂ Fe ₁₄ B-type magnet alloys (H.P.J. WIJN)	197
7.2.3.1	Introduction	197
7.2.3.2	Intrinsic properties	197
7.2.3.3	Sintered magnets	211
7.2.3.4	Melt-quenched magnets	223
7.2.3.5	References for 7.2.3	229
7.2.4	R ₂ Fe ₁₄ C-type magnet alloys (H.R. KIRCHMAYR, E. BURZO)	232
7.2.4.1	Introduction	232
7.2.4.2	Preparation, crystal structure and lattice parameters	232
7.2.4.3	Magnetization and Curie temperature	237
7.2.4.4	Magnetic structure	244
7.2.4.5	Hyperfine parameters determined by nuclear gamma resonance	245
7.2.4.6	Hyperfine parameters determined by nuclear magnetic resonance	251
7.2.4.7	Electrical resistivity	252
7.2.4.8	Specific heat	252
7.2.4.9	Magnetostriction	253
7.2.4.10	Magnetic anisotropy	253
7.2.4.11	Permanent magnet properties	257
7.2.4.12	References for 7.2.4	262
7.2.5	Rare-earth-iron interstitial compounds (E. BURZO)	265
7.2.5.1	General	265
7.2.5.1.1	Introduction	265
7.2.5.1.2	Relationship between ThMn ₁₂ - and Th ₂ Mn ₁₇ -structure types	266
7.2.5.1.3	Preparation of the alloys	267
7.2.5.2	R ₂ Fe ₁₇ A _x compounds with A = C, N, B or D(H)	269
7.2.5.2.1	Crystal structure and lattice parameters	269
7.2.5.2.2	Magnetization and Curie temperature	281
7.2.5.2.3	Magnetic structure	291
7.2.5.2.4	Hyperfine parameters determined by nuclear gamma resonance	293
7.2.5.2.5	Hyperfine parameters determined by nuclear magnetic resonance	301
7.2.5.2.6	Magnetic anisotropy	305
7.2.5.2.7	Magnetostriction	309
7.2.5.2.8	Permanent magnet properties	311

7.2.5.3	$\text{RFe}_{12-y}\text{M}_y\text{A}_x$ compounds	314
7.2.5.3.1	Crystal structure and lattice parameters	314
7.2.5.3.2	Magnetization and Curie temperature	316
7.2.5.3.3	Magnetic structure	318
7.2.5.3.4	Hyperfine parameters determined by nuclear gamma resonance	319
7.2.5.3.5	Magnetic anisotropy	320
7.2.5.3.6	Permanent magnet properties	322
7.2.5.4	References for 7.2.5	323