substance: boron compounds with lanthanides
property: properties of $MgAlB_{14}$ type orthorhombic borides with lanthanides

Structure: orthorhombic $MgAlB_{14}$ type

Space group: Imma or Ima2

Lattice parameters vs. metallic radii of metal atoms in Fig. 1 [91K].

$TbAlB_{14}$

On preparation and crystal habit see [94D].

lattice parameters
(in Å)

a	5.836(7)	*T* = 300 K	X-ray diffraction	91D2
b	10.419(9)			
c	8.189(8)			

magnetic moments

p_{eff}	11.0 μ_B	*T* = 150...250 K	88B
p_{theor}	9.72 μ_B		

Temperature dependence of 1/ σ_m ($\sigma_m \sim p_{eff}^2 /(T - \Theta)$) in Fig. 2 [88B].

paramagnetic Curie temperature

Θ	10 K	88B

microhardness
(for load *p* = 100 g, in kg mm^{-2})

H_K	2700/3400/2400	*T* = 300 K	(001) for azimuth 0/45/90°	94D
	2600		(011) for azimuth 45°	

$DyAlB_{14}$

On preparation and crystal habit see [94D].

lattice parameters
(in Å)

a	5.846(5)	*T* = 300 K	X-ray diffraction	91D2
b	10.420(6)			
c	8.198(5)			

magnetic moments

p_{eff}	12.1 μ_B	*T* = 150...250 K	88B
p_{theor}	10.63 μ_B		

Temperature dependence of $1/\sigma_m$ ($\sigma_m \sim p_{eff}^2 /(T - \Theta)$) in Fig. 2 [88B].

paramagnetic Curie temperature

Θ	– 13 K	88B

microhardness
(for load p = 100 g, in kg mm^{-2})

H_K	3700	T = 300 K	(001) for azimuth 90°	94D

$HoAlB_{14}$

On preparation and crystal habit see [94D].

lattice parameters
(in Å)

a	5.81...5.84	T = 300 K	X-ray diffraction	93W
b	8.18...8.27			
c	10.40...10.43			91K
needles				
a	5.816(1)	T = 300 K	X-ray diffraction	91D2
b	10.399(2)			
c	8.182(2)			
plates				
a	5.841(5)	T = 300 K	X-ray diffraction	91D2
b	10.410(6)			
c	8.188(5)			

magnetic moments

p_{eff}	11.8 μ_B	T = 150...250 K		88B
p_{theor}	10.60 μ_B			

paramagnetic Curie temperature

Θ	–16 K			88B

microhardness
(for load p = 100 g, in kg mm^{-2})

H_K	3800 / 3300 / 3000	T = 300 K	(001) for azimuth 0 / 45 / 90°	94D
	3400 / 2600		(011) for azimuth 0 / 45°	

$ErAlB_{14}$

On preparation and crystal habit see [94D].

lattice parameters
(in Å)

a	5.78...5.86	*T* = 300 K	X-ray diffraction	93W
b	8.17...8.22			
c	10.30...10.47			
a	5.8200(1)	*T* = 300 K	$Er_{0.62}Al_{0.73}B_{14}$, X-ray diffraction	92K2
b	8.1825(3)			
c	10.3950(4)			
a	5.8157(2)			93W
b	8.1816(3)			
c	10.3936(4)			
needles				
a	5.839(7)	*T* = 300 K	X-ray diffraction	91D2
b	10.390(9)			
c	8.171(8)			
plates				
a	5.842(5)			
b	10.406(6)			
c	8.186(5)			

atomic distances

(in Å)

d	2.27	Al – 12B	93W
	2.71	Er – 16B	
	2.91	Al – Al	
	3.17/3.40/3.64	Er – Er	

site occupancies

Er	0.310(1)	*T* = 300 K	$Er_{0.62}\,Al_{0.73}\,B_{14}$	92K2
Al	0.732(4)			
B(1) – B(5)	1			

Electronic properties

Relationship of electronic properties to those of quasicrystals in [97W].

energy gaps
(in eV)

E_g	0.33(3)	*T* = 300 K	deep level to band (probably due to Er)	93W
	0.97(1)		indirect allowed interband	
	1.30(1)		indirect allowed interband	

Lattice properties

phonon wavenumbers
(in cm^{-1})

ν/c	1536 1065 1027 930 902 873 801 778 761 711 691	T = 300 K	93W

Phonon spectrum in Fig. 3 [93W, 94W].

Optical properties

Optical absorption spectra of $ErAlB_{14}$ (compared with $LiAlB_{14}$ and $MgAlB_{14}$) in particular in the range of the absorption edge in Fig. 4 [93W].

Optical absorption spectra of $ErAlB_{14}$ (compared with $LiAlB_{14}$) in the range of single atom vibrations in Fig. 5 [93W].

Optical absorption spectra of $ErAlB_{14}$ (compared with $LiAlB_{14}$ and $MgAlB_{14}$,) in the range of the phonon frequencies in Fig. 6 [93W].

IR reflectivity spectrum and Drude fit in [94W].

Transport and further properties

electrical conductivity

σ	$3 \cdot 10^{-1}\ \Omega^{-1}cm^{-1}$	T = 300 K	94W

thermoelectric power

S	$-140(10)\ \mu V\ K^{-1}$	T = 300 K	94W

magnetic moments

p_{eff}	11.2 μ_B	T = 150...250 K	88B
p_{theor}	9.59 μ_B		

Temperature dependence of 1/ σ_m ($\sigma_m \sim p_{eff}^2/(T - \Theta)$) in Fig. 2 [88B].

paramagnetic Curie temperature

Θ	–19 K		88B

decomposition temperature

T_{decomp}		> 2000 K	93W

microhardness
(for load p = 100 g, in kg mm^{-2})

H_K	4100 / 3800 / 3400 3300 / 3100	T = 300 K	(001) for azimuth 0 / 45 / 90° (011) for azimuth 0 / 45°	94D

$TmAlB_{14}$

On preparation and crystal habit see [94D].

lattice parameters
(in Å)

a	5.8212(3)	*T* = 300 K	X-ray diffraction	93W
b	8.1762(3)			
c	10.3837(2)			92K1

microhardness
(for load *p* = 100 g, in kg mm^{-2})

H_K	3150 / 3400/3300	*T* = 300 K	(001) for azimuth 0 / 45 / 90°	94D

$YbAlB_{14}$

lattice parameters
(in Å)

a	5.860(3)	*T* = 300 K	X-ray diffraction	91D1
b	10.439(3)			
c	8.222(2)			

$LuAlB_{14}$

Preparation in [91D2].

lattice parameters
(in Å)

a	5.867(7)	*T* = 300 K	X-ray diffraction	91D2
b	10.364(8)			
c	8.157(7)			

References:

88B Brandt, N.B., Gippius, A.A., Mostshalkov, V.V., Ho H'u Nyan, Gurin, V.N., Korsukova, M., Kuz'ma, Yu.B.: Fiz. Tverd. Tela 30 (1988) 1380 (in Russian).

91D1 de Rooy, J.C.J.M., Reefman, D., van der Putten, D., Brom, H.B, Aselage, T., Emin, D.: in: Boron-Rich Solids, Proc. 10th Int. Symp. Boron, Borides and Rel. Compounds, Albuquerque, NM 1990 (AIP Conf. Proc. 231), D. Emin, T.L. Aselage, A.C. Switendick, B. Morosin, C.L. Beckel ed., American Institute of Physics: New York, 1991, p. 90.

91D2 Derkhachenko, L.I., Gurin, V.N., Korsukova, M.M., Nechitailov, A.A., Nechitailov, A.P., Kuz'ma, Yu.B., Chaban, N.F.: in: Boron-Rich Solids, Proc. 10th Int. Symp. Boron, Borides and Rel. Compounds, Albuquerque, NM 1990 (AIP Conf. Proc. 231), D. Emin, T.L. Aselage, A.C. Switendick, B. Morosin, C.L. Beckel ed., American Institute of Physics: New York, 1991, p. 451.

91K Korsukova, M.M.: in: Boron-Rich Solids, Proc. 10th Int. Symp. Boron, Borides and Rel. Compounds, Albuquerque, NM 1990 (AIP Conf. Proc. 231), D. Emin, T.L. Aselage, A.C. Switendick, B. Morosin, C.L. Beckel ed., American Institute of Physics: New York, 1991, p. 232.

92K1 Komai, M., Yamasaki, Y., Takagi, K.: Solid State Phenom. 25+26 (1992) 531.

92K2 Korsukova, M.M., Lundström, T., Tergenius, L.-E., Gurin, V.N.: J. Alloys Compounds 187 (1992) 39.

93W Werheit, H., Kuhlmann, U., Krach, G., Higashi, I., Lundström, T., Yu, Y.: J. Alloys Compounds 202 (1993) 269.

94D Derkachenko, L., Gurin, V., Korsukova, M., Nechitailov, Alexei, Nechitailov, Andrei: Proc. 11th Int. Symp. Boron, Borides and Rel. Compounds, Tsukuba, Japan, August 22 - 26, 1993, Jpn. J. Appl. Phys. Series 10 (1994), p. 144.

94W Werheit, H., Krach, G., Kuhlmann, U., Higashi, I., Lundström, T., Yu, Y.: Proc. 11th Int. Symp. Boron, Borides and Rel. Compounds, Tsukuba, Japan, August 22 - 26, 1993, Jpn. J. Appl. Phys. Series 10 (1994), p. 98.

97W Werheit, H., Schmechel, R., Kimura, K., Tmura, R., Lundström, T.: J. Solid State Chem. 133 (1997) 335 (Proc. 12th Int. Symp. Boron, Borides and Rel. Compounds, Baden, Austria, 1996).

Fig. 1.

$LnAlB_{14}$ ($MgAlB_{14}$-type lanthanide compounds). Lattice parameters vs. metallic radii of the metal atoms; data of $LiAlB_{14}$, $MgAlB_{14}$ (full circles), $MgMgB_{14}$ (crosses) and $Na_{1-x}B_{1-y}B_{14}$ (crossed oval circles) for comparison [91K].

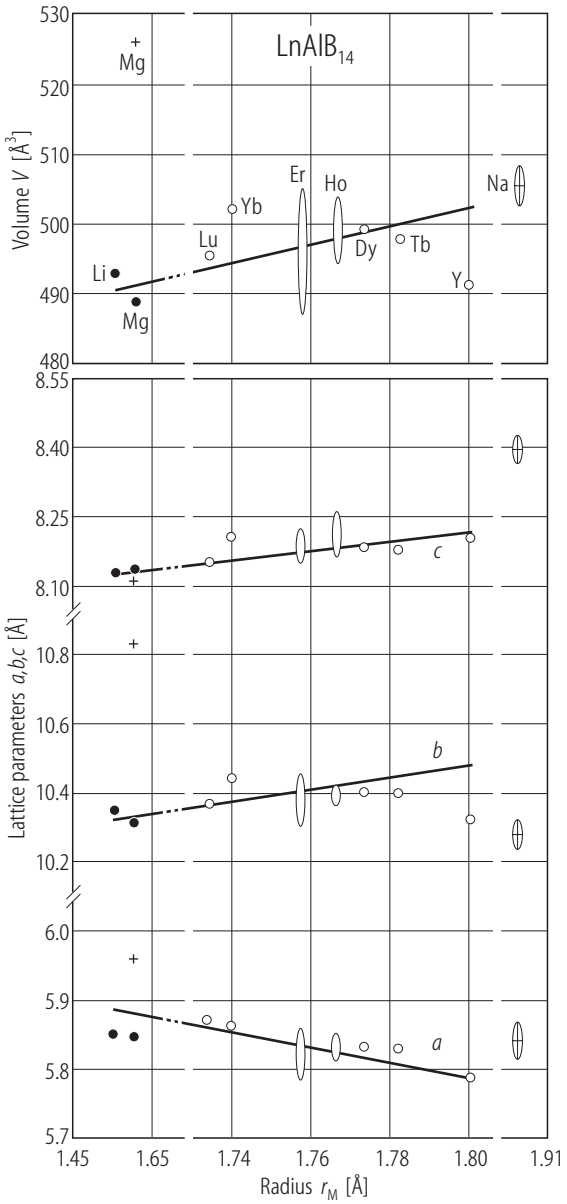

Fig. 2.

$LnAlB_{14}$ ($MgAlB_{14}$-type lanthanide compounds). Temperature dependence of the reciprocal molar magnetization $1/\sigma_m$ ($\sigma_m \sim p_{eff}^2/(T - \Theta)$) of single-crystal $TbAlB_{14}$, $DyAlB_{14}$, $ErAlB_{14}$ [88B].

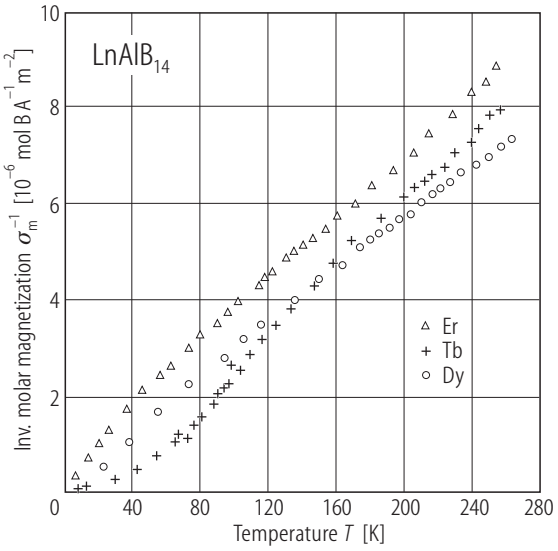

Fig. 3.

$ErAlB_{14}$. Absorption index vs. wavenumber. Spectra obtained by different experimental methods; *(1)* from reflectivity spectrum by KKR, *(2)* from transmission spectrum [93W, 94W].

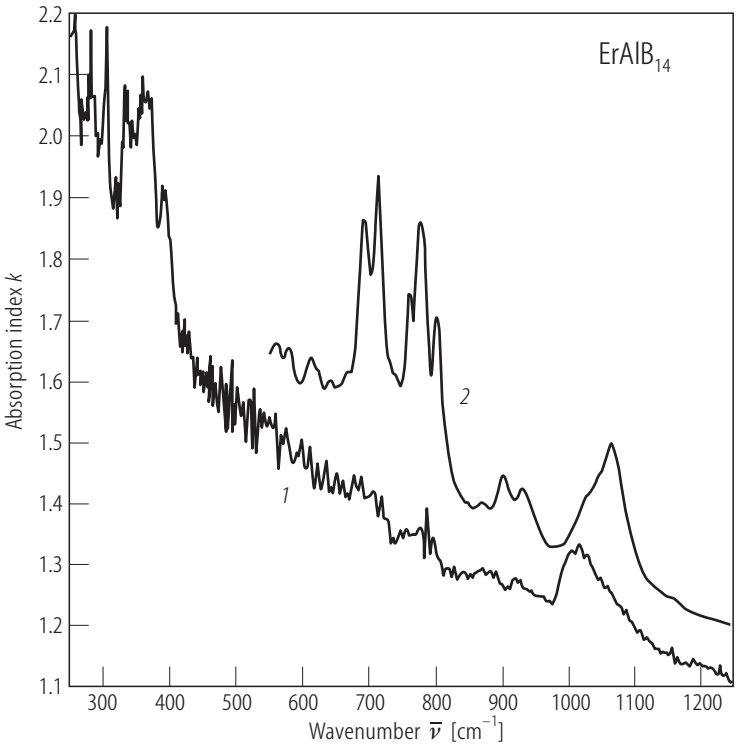

Fig. 4.

$MgAlB_{14}$ type orthorhombic structure group ($LiAlB_{14}$, $MgAlB_{14}$, $ErAlB_{14}$). Optical absorption spectra, in particular in the range of the absorption edge [93W].

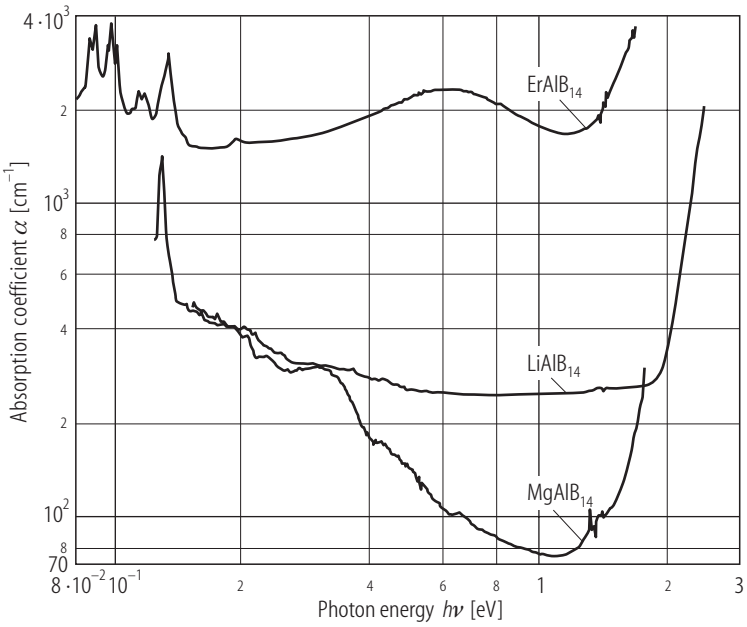

Fig. 5.

$MgAlB_{14}$ type orthorhombic structure group ($LiAlB_{14}$ (left ordinate), $ErAlB_{14}$ (right ordinate)). Optical absorption spectra in the range of single atom vibrations [93W].

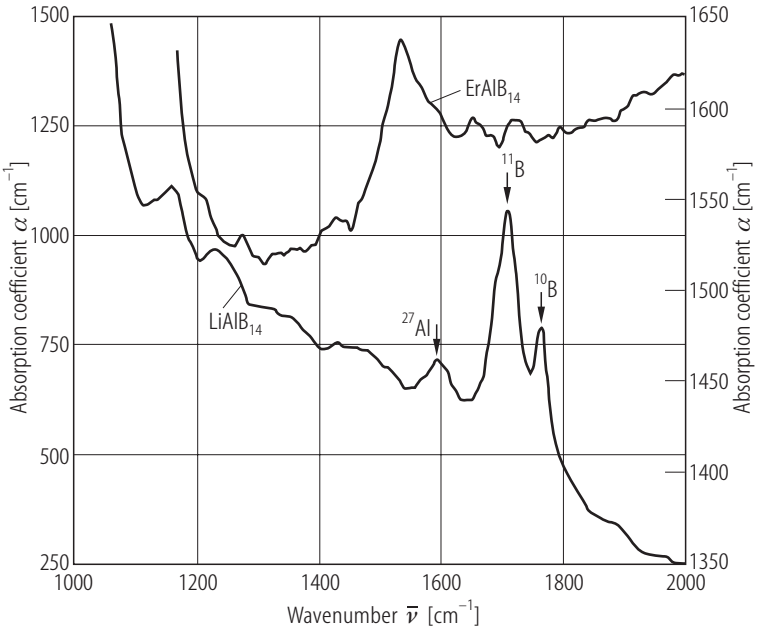

Fig. 6.

$MgAlB_{14}$ type orthorhombic structure group ($LiAlB_{14}$, $MgAlB_{14}$, $ErAlB_{14}$). Optical absorption spectra in the range of phonon frequencies [93W].