substance: boron compounds with group IV elements: boron carbide
property: boron carbide doped with Al

Al-doped boron carbide

Critical review on structures in [98M].

The crystal structure of Al-containing boron carbide [98H].

lattice parameters
(in Å)

$B_{12}AlC_2$ ($B_{12}Al_{0.25...0.75}C_2$)

a	5.63...5.68 Å	T = 300 K	X-ray diffraction	65E
c	12.29...12.45 Å			

$B_{12}AlC_2$

a	7.83(5)	T = 300 K	X-ray diffraction	66W
c	15.91			

$B_{12}AlC_4$ ($B_{13.34}Al_{0.33}C_{1.34}$)
Space group: $R\overline{3}m$

a	5.65 Å	T = 300 K	X-ray diffraction	66L
c	12.39 Å			

$B_{51}Al_2C_8$
Space group: $R\overline{3}m$

a	5.6561(8)	T = 300 K	X-ray diffraction, density d = 2.573 g cm^{-3}	98M
c	12.4424(12)			
V	344.72(7) Å^3			

$B_{10}CAl_{0.25}$

a	5.642	70N
c	12.367	
c/*a*	2.19	91L
V	340.9 Å^3	

B_4CAl_x

a	5.6640(3)	91L
c	12.4399(12)	
c/*a*	2.20	
V	345.61(5) Å^3	

Physical properties on a series of Al-doped boron carbides with Al contents between 0.2 and 1.43 at. %:

The Al sites in the boron carbide unit cell are shown in Fig. 1 [97S]. Al(1) and B(3) cannot simultaneously occupy their positions in the same unit cell. When B(3) is missing and an Al atom occupies the Al(1) position it is bonded to 9 atoms, namely 1C at 1.76 Å, 1B(1) at 1.96 Å, 2B(2) at 1.98 Å, 1C at 2.00 Å, 2B(1) at 2.15 Å and 2B(2) at 2.20 Å. However, such a hole would also be available if the three-atomic chain is missing altogether, and this possibility is preferable as an alternative, since in this case we would not have the very short A(1)-C distances at 1.76 and 2.00 Å, respectively. From the viewpoint of this structural consideration and based on the evidence of chain-free unit cells in undoped boron carbide (see there), the complete absence of three-atomic chains combined in principle with one or two Al atoms seems to be a probable structure models for Al-doped boron carbide. The existence of two-atomic chains (Al_2) like those known, e.g. for $B_{12}O_2$, $B_{12}P_2$ and $B_{12}As_2$ cannot be excluded. However, in contrast to these compounds the Al_2 chains would be arranged almost perpendicular to the c axis (only 7.2° inclination).

Phonon absorption spectra in Fig. 2 [97S].

Dependence of the thermoelectric power on the Al content in Fig. 3 [97S].

$AlB_{24}C_4$

p-type semiconductor

Preparation by hot pressing in [91K1].

The samples prepared by [91K1] are hot-pressed at 2000…2400 K. Therefore the boron-carbide related high-temperature phase has developed.

electrical conductivity

σ	$6\cdot10^{-2}\ \Omega^{-1}\text{cm}^{-1}$	T = 333 K	91K2

Temperature dependence of the electrical conductivity in Fig. 4 [91K2].

thermoelectric power

S	70 μV K^{-1}	T = 600 K	91K2
	250μV K^{-1}	T = 1000 K	

Temperature dependence of the Seebeck effect in Fig. 5 [91K2].

Effect of porosity on σ and S in [91K2].

References:

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98H Hubert, H., Garvie, L.A.J., Devouard, B., McMillan, P.F.: High Press. Mater. Res. 499 (1998) 315 (Mater. Res. Soc. Symp.).

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Fig. 1.

Boron carbide :Al. Al sites in the boron carbide unit cell together with the position of the central B(3) site [97S].

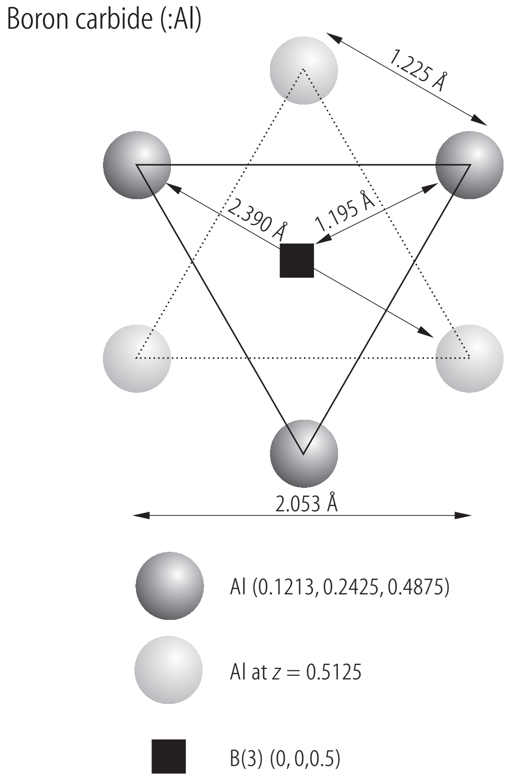

Fig. 2.

Boron carbide :Al. Absorption spectra of Al-doped boron carbide (Al content: 0.2...1.43 at. %) at 300 K [97S].

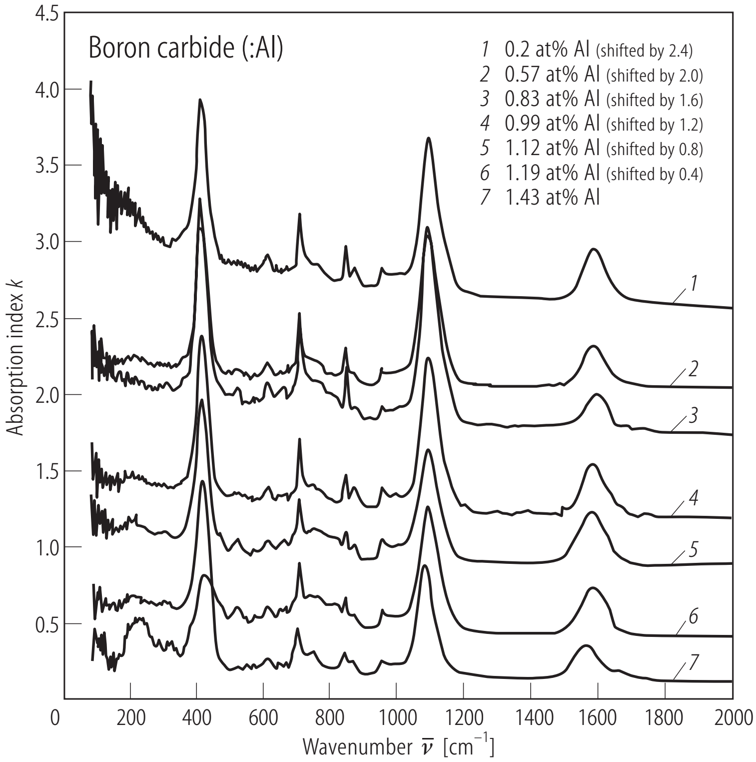

Fig. 3.

Boron carbide :Al. Thermoelectric power vs. Al content [97S].

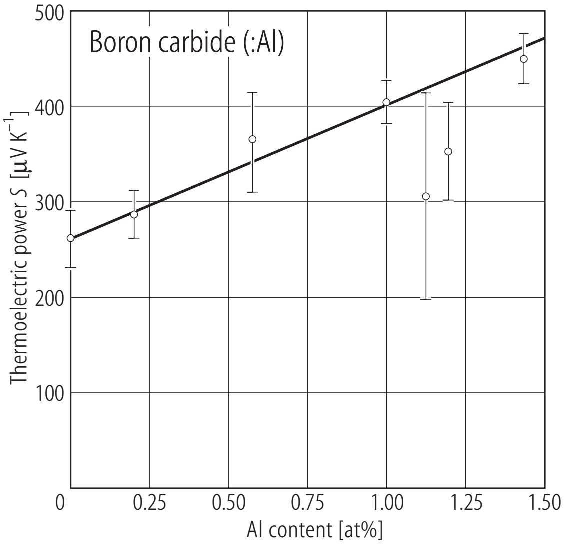

Fig. 4.

$AlB_{24}C_4$, $Al_8B_4C_7$. Temperature dependence of the electrical conductivity; σT vs. reciprocal temperature [91K2].

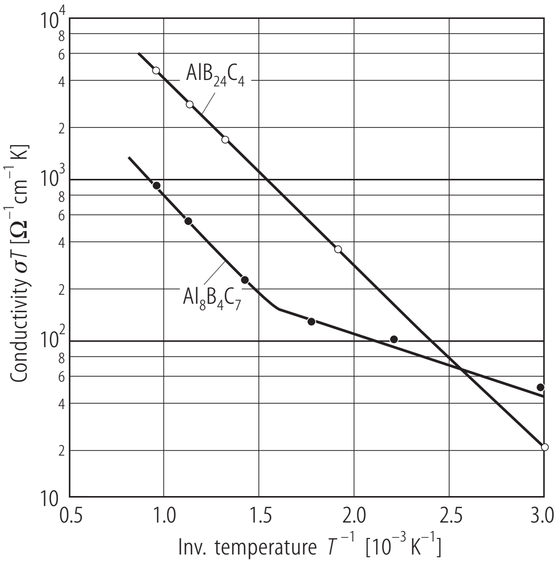

Fig. 5..

$AlB_{24}C_4$, $Al_8B_4C_7$. Temperature dependence of the thermoelectric power [91K2]. .