substance: boron compounds with group IV elements: boron carbide
property: boron carbide doped with N, P, O

The behavior of hydrogen, nitrogen and oxygen impurities in boron carbide (and aluminium dodecaboride) for gas sensors [91K].
Ternary metal boron carbide systems in [99B].

N-implanted boron carbide

Tribological properties in [91R].

Rutherford backscattering spectrum in Fig. 1 [91R].

Coefficients of friction in Fig. 2 [91R, 88D, 88N].

P-doped boron carbide

lattice parameters (for $(B_{11}C)$ $[(CBC)_{1-x}P_x)$

x	*a* [Å]	*c* [Å]	
0.00	5.599	12.070	93A
0.05	5.589(3)	12.014(9)	
0.10	5.598(3)	12.012(8)	
0.20	5.608(2)	12.023(5)	
0.35	5.614(2)	11.973(6)	
0.5	5.627(1)	11.990(2)	

PC, PB, and PP chains are thought to be possible, which sufficiently large interatomic distances to prevent bonding [94A].

activation energy for electrical conductivity

E_A	220 meV	T = 300...700 K	x = 0.05 in $(B_{11}C)(CBC)_{1-x}(CBP)_x$	94A
	240 meV		x = 0.1 in $(B_{11}C)(CBC)_{1-x}(CBP)_x$	

electrical conductivity
(σT in $K\,\Omega^{-1}cm^{-1}$)

σT	$8 \cdot 10^2$	T = 300 K	undoped	94A
	40		x = 0.05 in $(B_{11}C)(CBC)_{1-x}(CBP)_x$	
	15		x = 0.1 in $(B_{11}C)(CBC)_{1-x}(CBP)_x$	

Temperature dependence of the electrical conductivity of P-doped boron carbide in Fig. 3 [94A, 93A].

ac conductivities of undoped and P-doped boron carbide between 10^3 and 10^6 Hz in Fig. 4 [93A]

carrier densities
(in cm^{-3})

n	$2.2 \cdot 10^{20}$	undoped	94A
	$8.4 \cdot 10^{19}$	x = 0.05 in $(B_{11}C)(CBC)_{1-x}(CBP)_x$	
	$6.5 \cdot 10^{19}$	x = 0.1 in $(B_{11}C)(CBC)_{1-x}(CBP)_x$	

thermoelectric power

p-type (for x = 0.05 and x = 0.1 in $(B_{11}C)(CBC)_{1-x}(CBP_x)$ [94A].

Temperature dependence of the thermoelectric power in Fig. 5 [93A].

dielectric constant

Temperature dependence of the dielectric constant and loss tangents at 10^5 Hz in Fig. 6 [93A].

Raman effect

Raman spectra in Fig. 7 [93A] (see comment on conventionally measured Raman spectra of pure boron carbide).

O-doped boron carbide

Preparation at high pressure (reaction of mixtures of B, C, and B_2O_3 at 5...7.5 GPa) [97H].

For phase diagram, see [97G].

lattice parameters
(in Å)

a	5.570(2)	*T* = 300 K	$B_6C_{1.1}O_{0.33}$ X-ray diffraction	97H
c	12.117(3)			
a	5.582(1)	*T* = 300 K	$B_6C_{1.28}O_{0.31}$ X-ray diffraction	97H
c	12.135(3)			

electronic properties

Parallel electron-energy-loss spectra (PEELS) of O-doped boron carbide compared with some other isostructural compounds in Fig. 8 [97G].

N, O-doped boron carbide

Composition $B_6C_{0.91}(N, O)_{0.27}$ in [97G].

For PEELS spectrum, see Fig. 8 [97G].

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Fig. 1.

Boron carbide :N. **(a)** Rutherford backscattering spectra of nitrogen-implanted and unimplanted boron carbide and **(b)** their difference showing the implantation profile [91R]. Nominal composition is B_4C, probably close to the carbon-rich limit of the homogeneity range $B_{4.3}C$.

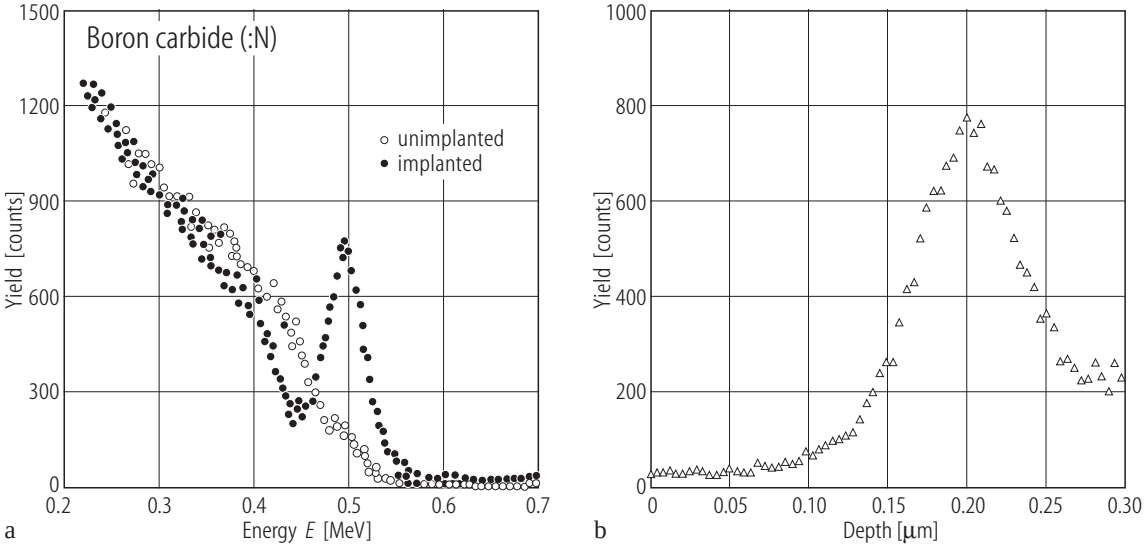
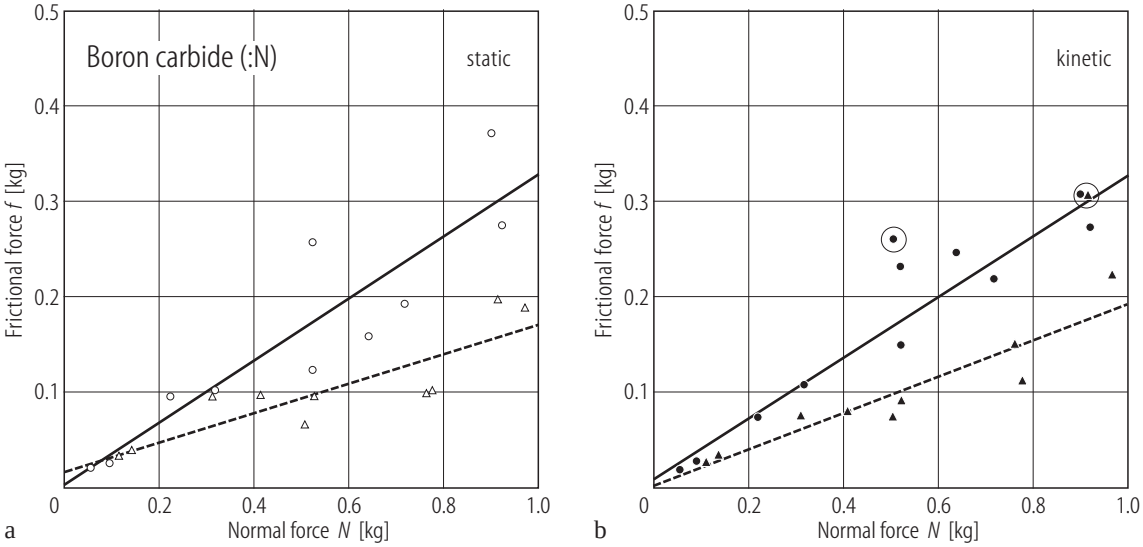


Fig. 2.

Boron carbide :N. coefficients of friction for Beta Ti wire against boron carbide that has been unimplanted (circles) or N^+ implanted (triangles); **(a)** static, **(b)** kinetic. The highlighted data points exceeded Chauvenet's criterion and were not included in the regression analysis [91R]. For composition see Fig. 1.



a b

Fig. 3.

Boron carbide :P. Electrical conductivity (σT) vs. reciprocal temperature; P-doped samples (x = 0.05 and 0.10 respectively in the assumed compound $(B_{11}C)(CBC)_{1-x}(PB)_x$) compared with undoped boron carbide. [93A, 94A].

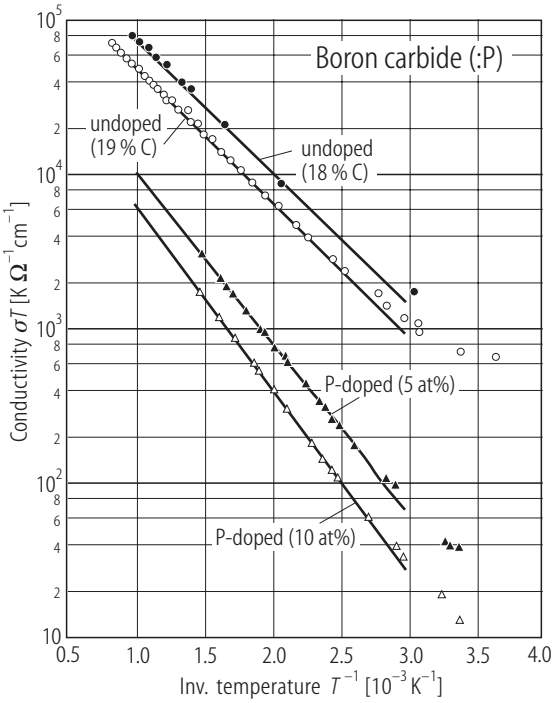


Fig. 4.

Boron carbide :P. ac conductivity between 10^3 and 10^6 Hz vs. temperature. P doped boron carbide (x = 0.05 in the assumed compound $(B_{11}C)(CBC)_{1-x}(PB)_x$) compared with undoped boron carbide (18 at% C, dashed lines) vs. temperature [93A]. $\sigma_0 = 1\ \Omega^{-1}cm^{-1}$.

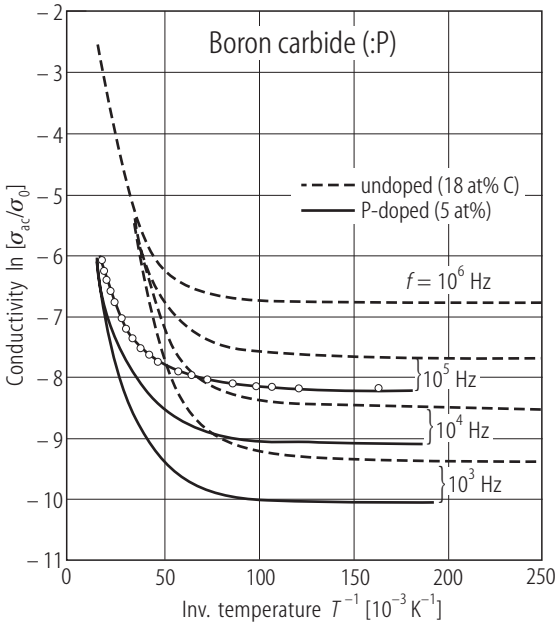


Fig. 5.

Boron carbide :P. Thermoelectric power of P-doped boron carbide (x = 0.10 in the assumed compound $(B_{11}C)(CBC)_{1-x}(PB)_x$) vs. temperature [93A].

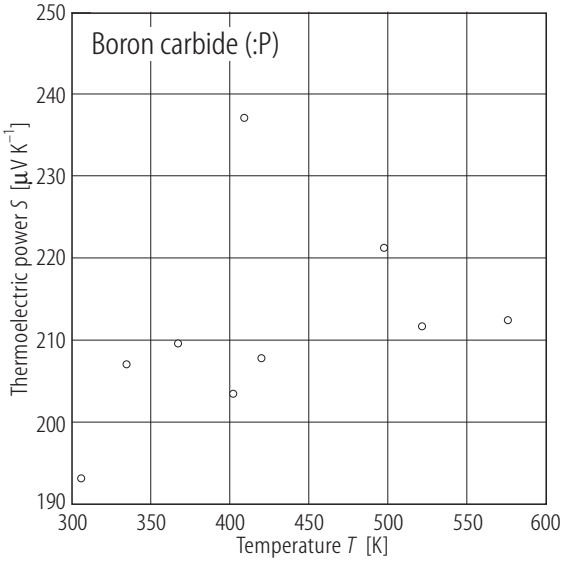


Fig. 6.

Boron carbide :P. **(a)** Real part of the dielectric constant and loss tangent at 10^5 Hz vs. temperature. Undoped boron carbide (18 at% C) (-.-.-) and P-doped boron carbide (------, x = 0.05, ———, x = 0.10) in the assumed compound $(B_{11}C)(CBC)_{1-x}(PB)_x$) [93A]. Fig. **(b)** shows ε_1 at 4 K as a function of frequency.

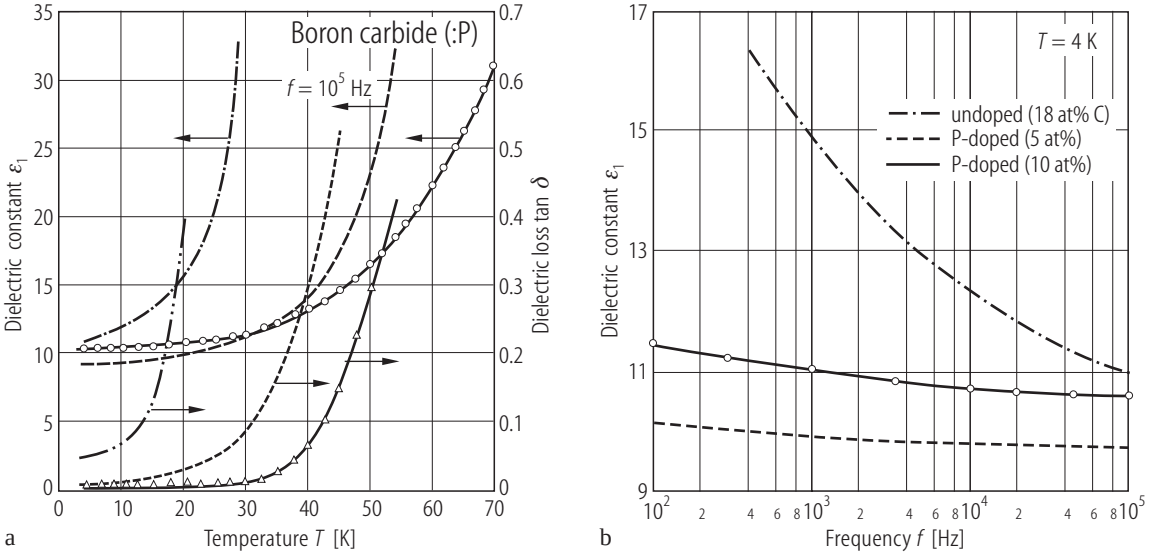


Fig. 7.

Boron carbide :P. Raman intensity vs. Raman shift for P-doped boron carbide (x = 0.05, 0.10, 0.20, 0.35 in the assumed compound $(B_{11}C)(CBC)_{1-x}(PB)_x$) compared with undoped boron carbide (19 at% C) [93A].The Raman spectra were obtained with the conventional Raman spectroscopy using high energies of the exciting laser [93A, 94A].

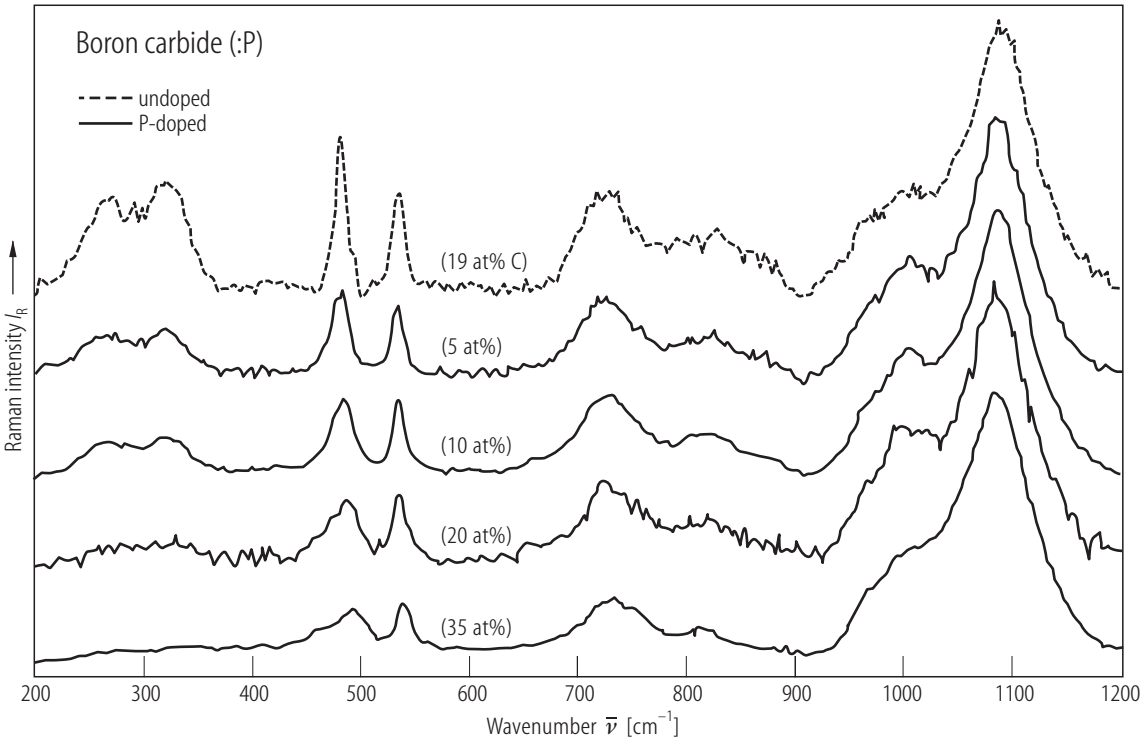


Fig. 8.

Boron carbide:O. Parallel electron energy-loss spectra (PEELS) of O-doped boron carbide compared with some other isostructural compounds ($B_6N_{0.92}$, $B_6O_{0.96}$, $B_6N_{0.52}O_{0.51}$, $B_6C_{0.91}(N,O)_{0.27}$ (background subtracted) [97G].