substance: hematite (α-Fe_2O_3)
property: carrier concentration, electrical conductivity in pure Fe_2O_3

intrinsic carrier concentration

n_i	$3.95 \cdot 10^{22}$ exp(–1.8[eV]/2kT) cm^{-3}]	T in K	63G

The value of 1.8 eV is close to the reported indirect optical threshold [63G, 79K1]. The origin of this transition would in principle be $Fe^{3+} + Fe^{3+} \to Fe^{4+} + Fe^{2+}$ or $Fe^{3+} + O^{2-} \to Fe^{2+} + O^{-}$. Cluster calculations support the first assignment [74T] whereas the optical data discussed below favours the second.

conductivity

Three distinct regions for air-fired samples are observed (Fig. 1, see also Fig. 3).

(A) Region of variable activation energy, $T \leq$ 450°C. Conductivity dominated by grain boundary resistance in polycrystalline samples, with $E_A \approx$ 0.7 eV. This region can be minimized by cooling under a reducing atmosphere. Grain boundary effects are clearly demonstrated by ac conductivity [51M].

(B) Region of low activation energy, 450°C ≤ T ≤ 800°C; $E_A \approx$ 0.1 eV. Ascribed to extrinsic conduction with "frozen-in" equilibrium.

parameters in the formula $\sigma = n_d e A/T \exp(-\alpha/kT)$:

n_d	$4.5 \cdot 10^{18}$ cm^{-3}	firing	n_d: quenched donor concentration,	63G
A	2270 cm^2 K/Vs	temperature	A: constant, a: activation	
α	0.31 eV	T = 1000°C	energy for electron mobility.	
n_d	$1.7 \cdot 10^{19}$ cm^{-3}	T = 1100°C	Samples are ceramics.	
A	207 cm^2 K/Vs			
α	0.22 eV			
n_d	$5.5 \cdot 10^{19}$ cm^{-3}	T = 1200°C		
A	44 cm^2 K/Vs			
α	0.13 eV			
n_d	$1.5 \cdot 10^{20}$ cm^{-3}	T = 1300°C		
A	42 cm^2 K/Vs			
α	0.12 eV			
n_d	$4 \cdot 10^{20}$ cm^{-3}	Fe_2O_3		
A	232 cm^2 K/Vs	+ 1.0 at% Ti		
α	0.10 eV			

For unfired samples, containing no Fe^{2+}, the region of low activation energy is far smaller, and the intrinsic region extends to much lower temperatures (Fig. 2) [63G].

Higher activation energies have been reported for this region: 0.39 eV [65G], 0.38 eV [48B]. Activation energy decreases strongly with Fe^{2+} concentration [63G].

(C) Intrinsic region, T > 800°C.

activation energies in region (C)

E_A(= $E_{g,th}$/2)	1.15 eV	all samples are ceramics	65G
	1.0 eV		63G
	1.17 eV		51M
	1.15 eV		71R
	1.06 eV		48B

Resistance varies strongly with applied hydrostatic pressure; there is a collapse to a low-resistivity phase at ≈ 440...520 kbar [79K2].

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Fig. 1.

Fe_2O_3. Conductivity vs. reciprocal temperature for high-purity samples (i) polycrystalline bar sintered at 1300°C in O_2 and cooled to 900°C in ca. 30 min., (ii) polycrystalline bar sintered at 1300°C in O_2 and quenched rapidly to 20°C, (iii) polycrystalline bar sintered at 1300°C and cooled slowly to RT, (iv) oxidized iron wire heated to 1300°C for 5 h and rapidly quenched to 20°C. A, B, C are the regions discussed in the tables. Solid circles: single crystal flux grown from sodium tetraborate; four-probe resistivity along the (111) plane of a specimen quenched after 13 h at 1300°C in air [63G].

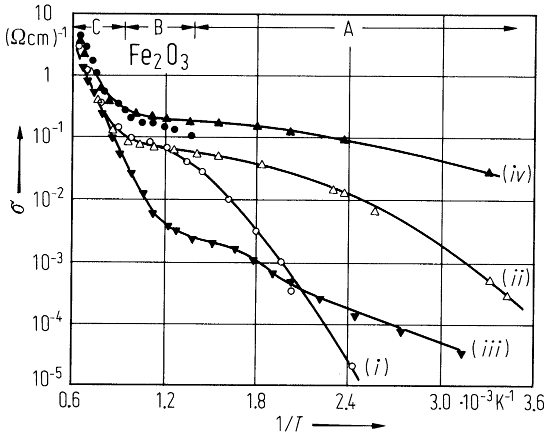

Fig. 2.

Fe_2O_3. (a) Conductivity vs. reciprocal temperature of an unfired compact between 400ºC and 600ºC, open circles: temperature rising, full circles: temperature falling; (b) influence of firing temperature on the conductivity of a compact sample, (i) unfired compact, (ii)-(vi) curves obtained for specimen quenched after 20 h at the stated temperatures [63G]. Ceramic samples.

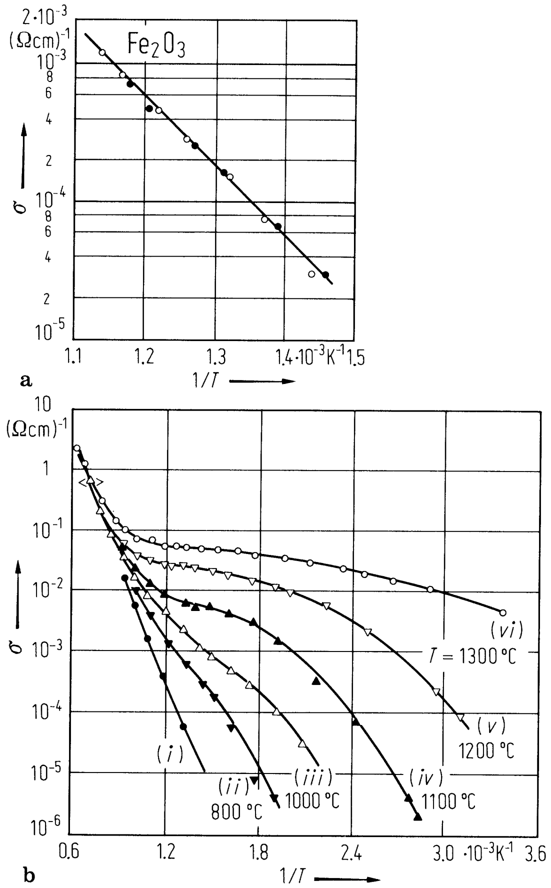

Fig. 3.

Fe_2O_3:Mg. Conductivity vs. reciprocal temperature for Mg doped ceramic samples fired at 1300°C. (*1*) pure sample, (*2*) 0.01 at% Mg, (*3*) 0.03 at% Mg, (*4*) 0.05 at% Mg, (*5*) 0.2 at% Mg [66G].