substance: Co_3O_4
property: electrical conductivity, Seebeck coefficient

conductivity: Fig. 1. p-type semiconductor with room temperature resistivity of ≈ 10^4 Ω cm.

activation energy for conductivity

E_A	0.4 eV	T = 400...600 K		79G
	0.68 eV	T = 450...500 K	$Co_3O_{4.02}$	38H

Seebeck coefficient

S	600 μV K^{-1}	T = 300 K	78A
	1050 μV K^{-1}	T = 300 K	79G

Co_3O_4 can be synthesized grossly cation deficient [78B]. X-ray measurements indicate that the cation vacancies order to provide solid solutions between Co_3O_4 and the hypothetical defect spinel γ-Co_2O_3. The formulation $Co(Co_{2-x}^{3+}Co_{x/4}^{4+}vac_{3x/4})O_4$ has been suggested [78B] and conductivity and Seebeck data for films of non-stoichiometric oxide are shown in Fig. 2.

On doping with Zn the material remains p-type and semiconducting (Fig. 3). Doping with Ni leads to a semiconductor-semimetal transition at x ≈ 0.5 (Fig. 4). Doping with Li has a marked effect on conductivity, a increasing from ≈ 10^{-5} $Ω^{-1}$ cm^{-1} to ≈ 1 $Ω^{-1}$ cm^{-1} at 1 at% Li and RT [77V].

References:

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Fig. 1.

Co_3O_4, $Co(Ni_xCo_{2-x})O_4$ ceramic. Resistivity vs. reciprocal temperature for various x [78A].

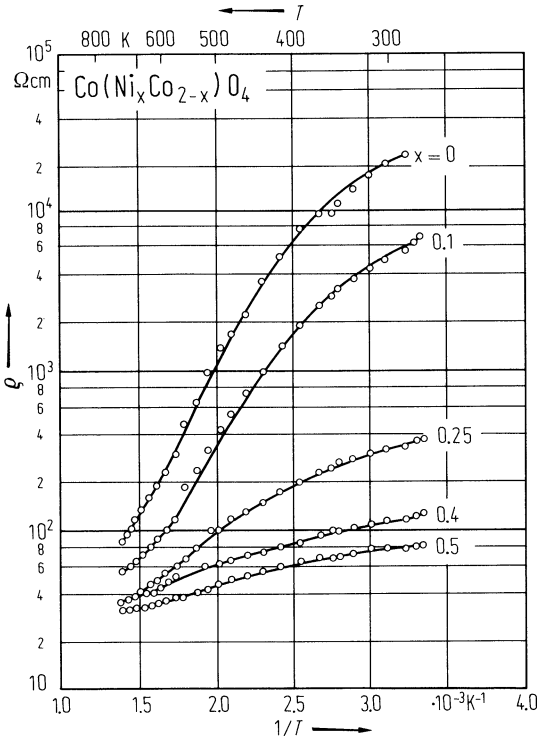

Fig. 2.

$Co_{3-\delta}O_4$ film. I and II: conductivity vs. reciprocal temperature for films annealed at 350ºC and 400ºC, respectively. III: Seebeck coefficient vs. reciprocal temperature for a Co_3O_4 film annealed at 400ºC [78B].

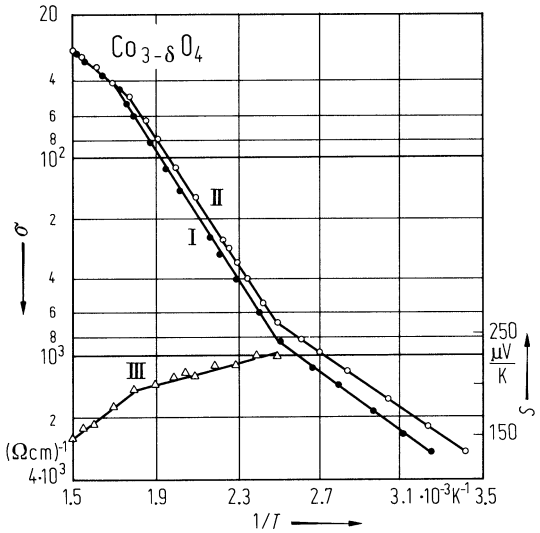

Fig. 3.

$(Zn_xCo_{1-x})Co_2O_4$ ceramic. Room temperature resistivity vs. composition [77V].

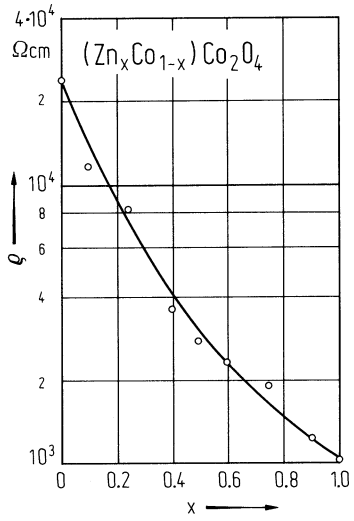

Fig. 4.

$Co(Ni_xCo_{1-x})O_4$ ceramic. Room temperature resistivity vs. composition [77V].