Letters to the Editor

DISTRIBUTION OF Ni^{2+} IONS IN NaCl SINGLE CRYSTALS AND THEIR ELECTRIC CONDUCTIVITY

РАСПРЕДЕЛЕНИЕ ИОНОВ Ni^{2+} В МОНОКРИСТАЛЛАХ NaCl И ИХ ЭЛЕКТРОПРОВОДНОСТЬ

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A distribution coefficient defined as the ratio of the concentration of an impurity in the crystal to that in the melt is one of the most important parameters in evaluating a distribution of an impurity in an ingot. Distribution coefficients in alkali halides have been studied by different methods as a function of the growth rate [1, 2] and the initial concentration [3, 4]. Andreev et al. [2, 3] have published papers on the relation between the distribution coefficients of various impurities and their ronic radii. The value of 0.13 ± 0.03 has been obtained by Ikeya et al. [5] for the distribution coefficient of Ni^{2+} in NaCl grown by zone melting.

The transport parameters of such systems investigated by the method of electrical conductivity, dielectric losses, etc. can be found, e.g. in papers [8, 9].

The aim of this short note was to determine the distribution of Ni^{2+}ions in NaCl single crystals grown by the Stockbarger method and to use the samples with the defined content of Ni^{2+} for future investigation of the kinetics of impurity aggregation and precipitation processes.

The starting NaCl material was purified of heavy ion impurities by chemical extraction. OH^- groups in the melt were removed by $SiCl_4$-vapour treatment. From the purified and Ni^{2+}-doped material contained in vacuum sealed quartz ampoules the crystals were grown by the Stockbarger method. The rate of crystal growth was kept constant at 0.9 mm per hr. The crystals were annealed after growing for 24 hrs at 750 °C and then cooled to room temperature in the growing ampoule.

The nickel concentration in the crystal layers was estimated by atomic absorption analysis (Perkin) — Elmer Spectrophotometer — Model 403. The detection limit (the smallest concentration which can be quantitatively estimated in water solution) for nickel is 0.01 g/ml.

The size of samples used for the electric conductivity measurements, σ, was $0.6 \times 0.6 \times 0.1$ cm^3. The surfaces were coated by graphite electrodes. Both, the thermal treatment and the measurement of σ, were carried out in an inert atmosphere. The thermal treatment of samples consisted of annealing at temperatures 720 °C for 16 hrs and of the following cooling to room temperature. The measurements of σ were carried out in the temperature region 25—650 °C by the methods of the dc technique described in [6, 7].

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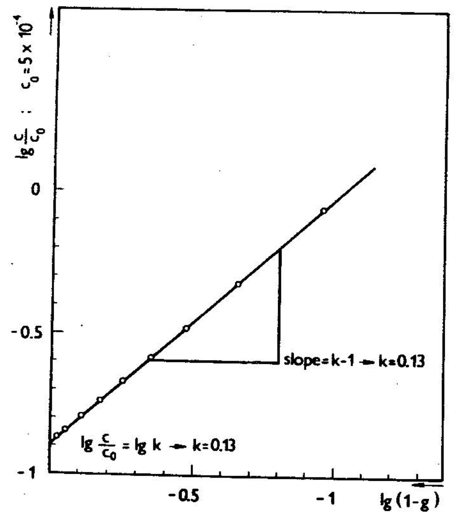

Fig. 1. Ni^{2+} concentration as a function of crystal length according to Pfann's equation.

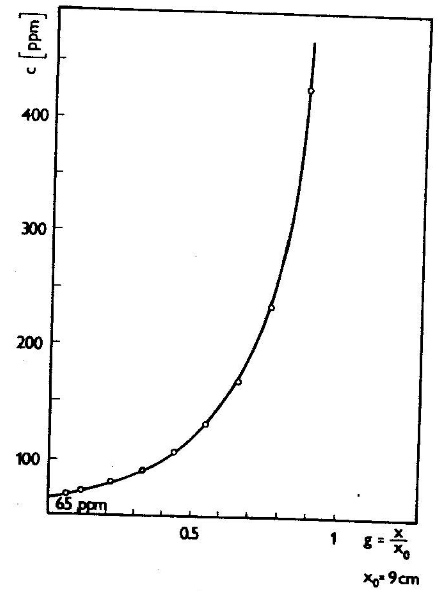

Fig. 2. Distribution of Ni^{2+} ions along the crystal : C vs $g = x/x_0$.

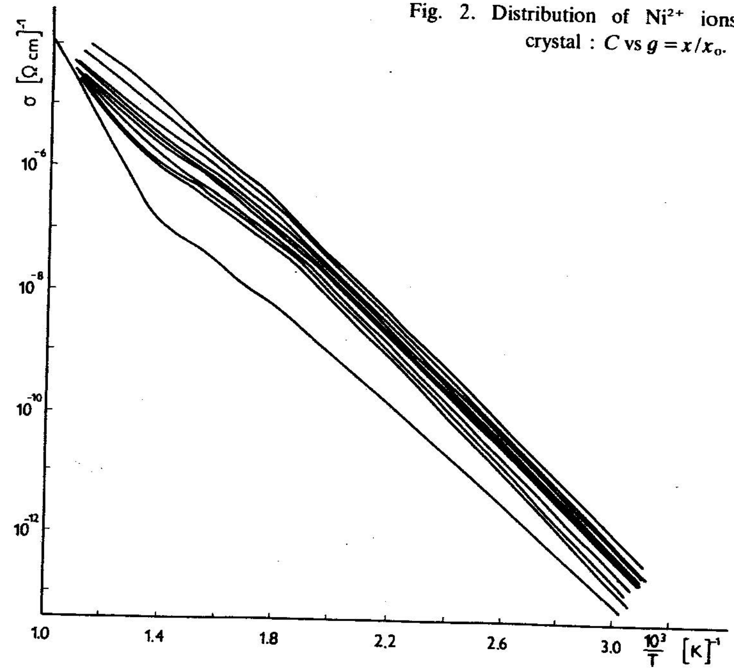

Fig. 3. Electrical conductivity of definite NaCl crystal layers with various nickel contents.

The distribution coefficient of Ni^{2+} was determined by estimating the Ni^{2+} content by the atomic absorption analysis as the function of the crystal length and by plotting log c/c_o vs log $(1-g)$ according to Pfann's equation [10]

$$\frac{c}{c_0} = k(1-g)^{(k-1)},$$

where c_o – Ni^{2+} concentration in the melt, c – Ni^{2+} concentration at a definite layer of the crystal, k – distribution coefficient, g – fraction of the solidified melt, in our case proportional to the fraction of the length of the cylindrical crystal corrected for the rounded bottom.

The obtained results are presented in Figs. 1 and 2. The Ni^{2+} concentration in the melt $c_o = 5 \times 10^{-4}$ m. fr., and the crystal length $x_o = 9$ *cm*.

The distribution coefficient estimated as the ratio of the nickel content extrapolated to the "pure" end of the crystal ($g = 0$) to the nickel content in the original melt amounts to 0.13 (Fig. 1) and agree quite well with that obtained from the slope of lg c/c_o vs lg $(1-g)$ graph (Fig. 1). The distribution of Ni^{2+} along the crystal length can be seen in Fig. 2. The value of $k = 0.13$ obtained in the present paper is in good agreement with that obtained by Ikeya et al. [5] for the crystal grown by zone melting, 0.13 ± 0.03.

To verify the chemically estimated Ni^{2+} concentration in definite crystal layers, measurements of electrical conductivity σ were used. In Fig. 3 there is plotted the electrical conductivity of definite crystal layers as a function of reciprocal temperature. It can be seen that the electrical conductivity increases in this case in agreement with an increasing Ni^{2+} content along the crystal length.

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