PHOTOSTIMULATED EXOELECTRON EMISSION FROM UNIAXIALLY STRAINED KCl AND NaCl CRYSTALS PREVIOUSLY COLOURED WITH *X*-RAYS

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The photostimulated exoelectron emission from uniaxially strained KCl and NaCl crystals previously coloured with *X*-rays is investigated. It is found that the intensity of exoelectron emission of all examined samples, kept prior to measurement in an exsiccator containing P_2O_5, achieved maximum value in the vicinity of the transition of deformations from the elastic to the plastic region during uniaxial compression.

1. Introduction

The first measurements of exoelectron emission accompanying deformation of NaCl crystals coloured witch *X*-rays were carried out by Bigos *et al.* [1] and Piróg *et al.* [2]. It follows from these studies that photostimulated exoelectron emission from uniaxially strained crystals is associated with the region of plastic deformation and that the kinetics of exoelectron emission depends on the kinetics of the forces acting on the sample. Subsequent studies by Piróg and Sujak [3—7] showed that photostimulated exoelectron emission is associated with *F* centers. These authors found that maximum intensity of exoelectron emission appears in the region of plastic deformations of a crystal. In the cited papers the samples were stored prior to measurement in atmospheric air.

In this work, exoelectron emission measurements were extended to uniaxially strained KCl crystals, and measurements on NaCl crystals were repeated. The grown crystals and

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the samples were stored until measurement in an exsiccator containing P_2O_5 in order to safeguard the surface layer against the effect of atmospheric air and in particular water vapour.

Special attention was paid to the effect of water vapour in the air on the location of the maximum in the emission intensity *versus* sample strain curve. It was ascertained that the position of this peak strongly depends on the sample's history.

2. Equipment

The sample was submitted to uniaxial compression in a device like that used by Piróg and Sujak [2] with an additional sensing element for making a parallel recording of the change in crystal length and the intensity of exoelectron emission. The scheme of this device is shown in Fig. 1.

The mobile jaw of the deforming device moved the "pusher" of the sensing element which by a system of levels changed the position of the slider of the potentiometer R_c.

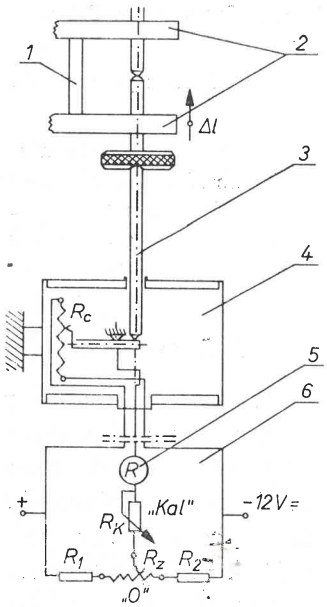

Fig. 1. Diagram of electric sensing element for recording deformations. *1* — sample being examined, *2* — jaw of deforming device, *3* — pusher, *4* — electric sensing element, *5* — recorder, *6* — bridge circuit

This potentiometer was connected in the circuit of a d. c. bridge and constituted two of its branches. The unbalanced current of the bridge, being a linear function of the displacement of the "pusher", caused the indicator of the recorder R to deviate accordingly. The dependence of indicator deviation on changes in crystal length is shown in Fig. 2. It is linear in the range of length changes from 0 to 2 mm. This range comprises the deformation measurements made for the samples in mention.

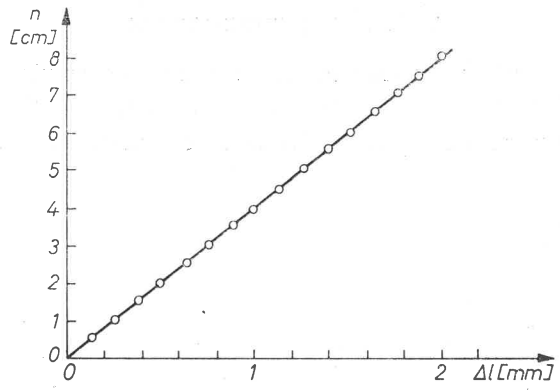

Fig. 2. Dependence of recorder pen deviation n on magnitude of sample deformation Δl (n stands for the number of divisions of the recorder tape, Δl — means change of crystal length)

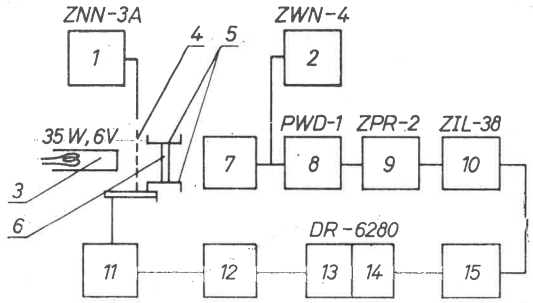

Fig. 3. Diagram of measuring arrangement. *1* — power supply, *2* — high voltage supply, *3* — microscope lamp, *4* — copper grid, *5* — jaws of deforming device, *6* — examined sample, *7* — horizontal point counter, *8* — preamplifier, *9* — electronic scaler, *10* — linear integrator, *11* — electric sensing element, *12* — amplifier, *13* and *14* — double pen recorder, *15* — amplifier

Measurements were carried out with a typical arrangement, a diagram of which is shown in Fig. 3. The detector of pulses was a horizontal point counter with quenching vapour above the free surface of ethyl alcohol [8, 9].

3. *Sample preparation*

KCl and NaCl single crystals were grown by the modified Kyropoulos method from analytically pure potassium chloride and sodium chloride.

Samples of dimensions $2 \times 2 \times 10$ mm were cleaved and then annealed. The annealing temperature for KCl was 893 K and for NaCl 923 K. After a ten-hour period of annealing the samples at the cited temperatures, there followed a period of slow cooling down to room temperature, lasting a dozen-odd hours.

Sample colouring was conducted in a "Stabil 250" X-ray apparatus with a tungsten cathode, $I_a = 8$ mA, $U_a = 85$ kV. Colouring time was 15 minutes.

All samples except one of the NaCl series were stored in the exsiccator containing P_2O_5.

4. *Results of measurements*

The dependence of relative strain and intensity of photostimulated exoelectron emission on the compressive stress is shown in Fig. 4 for the KCl crystals and in Fig. 5 for the NaCl crystals. Each experimental point is the arithmetic mean of results obtained for ten samples.

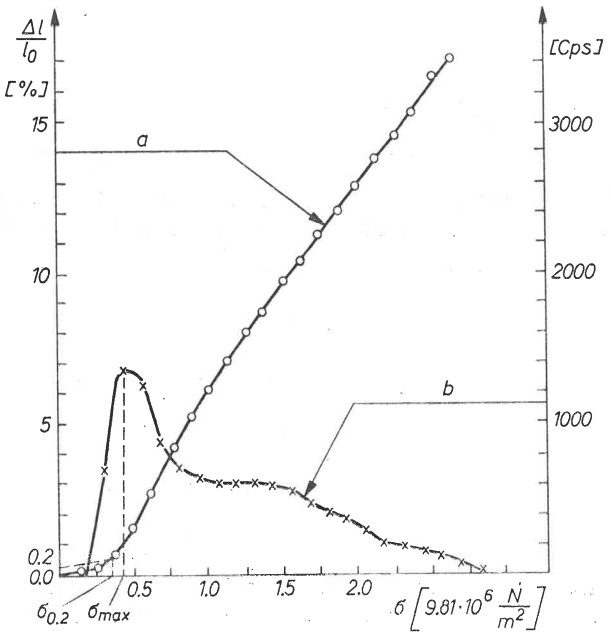

Fig. 4. Dependence of relative deformation $\Delta l/l_0$ and intensity of exoelectron emission N/t on compressing stress σ for KCl crystals annealed at 893 K

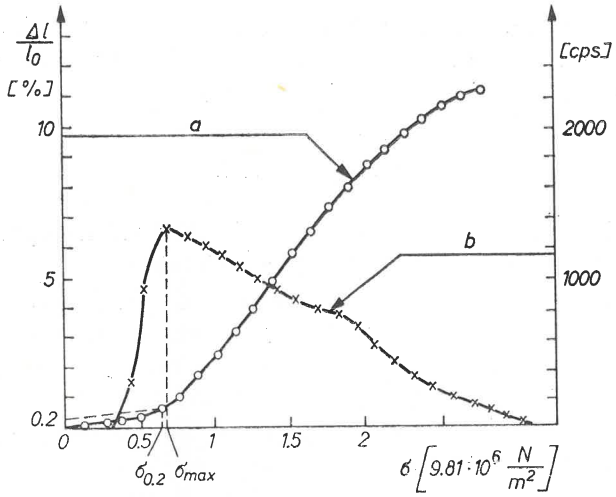

Fig. 5. Dependence of relative deformation $\Delta l/l_0$ and intensity of exoelectron emission N/t on compressing stress σ for NaCl crystals annealed at 923 K

The dashed lines in the graphs mark out the conventional plasticity limit $\sigma_{0.2}$ [10, 11] and the stress σ_{max} corresponding to maximum intensity of exoelectron emission. For the KCl crystals these values are $\sigma_{max} = 0.43\ [9.81 \times 10^6]\ N/m^2$, $\sigma_{0.2} = 0.36\ [9.81 \times 10^6]\ N/m^2$ and for NaCl crystals $\sigma_{max} = 0.63\ [9.81 \times 10^6]\ N/m^2$, $\sigma_{0.2} = 0.60\ [9.81 \times 10^6]\ N/m^2$.

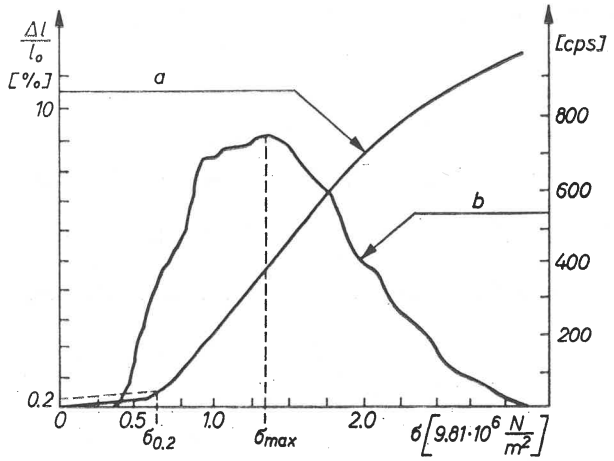

Fig. 6. Dependence of relative deformation $\Delta l/l_0$ and intensity of exoelectron emission N/t on compressing stress σ for NaCl samples stored in atmospheric air prior to measurement

Such dependences were obtained for all of the samples kept in the exsiccator containing P_2O_5 prior to measurement.

For the series of NaCl samples stored for several days in atmospheric air of relative humidity 55% there is no observable change in the value of plasticity limit, but the maximum intensity of exoelectron emission becomes shifted to the value of stress $\sigma_{max} = 1.3\ [9.81 \times \times 10^6]\ N/m^2$. The relevant curves for the NaCl samples of this series are shown in Fig. 6.

5. *Discussion of results*

The plasticity limits determined for the KCl and NaCl crystals are higher than those quoted by various authors [12—15] for "pure" crystals. The analytically pure sodium chloride used for preparing samples contained, according to the manufacturer, about 0.1% of various impurities, while the potassium chloride had about 0.5% of impurities, including a substantial quantity of bivalent ions. These impurities undoubtedly bear an effect on the properties of the examined samples and are responsible for the observed heightening of the plasticity limit.

It follows form the presented curves in Figs 4 and 5 that the maximum intensity of photostimulated exoelectron emission for uniaxially strained crystals is associated with the vicinity of the transition of deformations from the elastic region to the plastic region. For KCl crystals the difference between σ_{max} and $\sigma_{0.2}$ relative to $\sigma_{0.2}$ does not exceed 19%, whereas for NaCl crystals this value does not exceed 5%.

The value of σ_{max} obtained for NaCl crystals is closer to the plasticity limit than analogous values obtained in earlier studies [3, 4]. This stems from the conditions under which the samples were stored prior to exoelectron emission measurements. For samples stored in atmospheric air large shifts of the exoemission intensity maximum towards the higher stress values are also observed in this work (Fig. 6). This shift may be caused by the action of some constituents of atmospheric air, especially water vapour, giving a change in the state of the crystal's surface layer.

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