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THERMOEXOEMISSION (TEE) FROM IONIC CRYSTALS X-RAYED AT LIQUID HELIUM TEMPERATURE

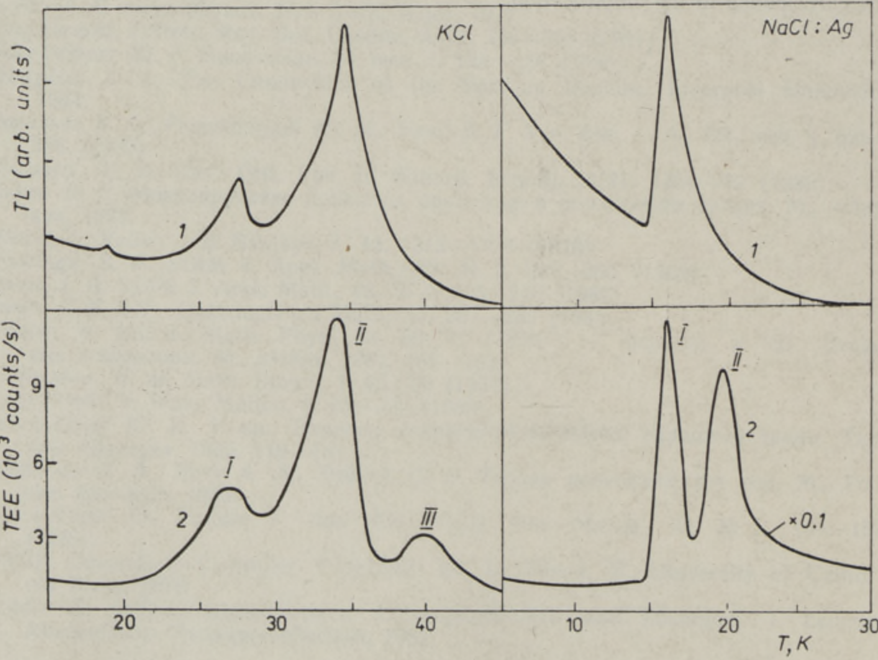
V. BITŠEVIN, H. KÄÄMBRE. VEDELA HEELIUMI TEMPERATUURIL RÖNTGENKIIRITATUD IOONKRISTALLIDE TERMOEKSOEMISSIOON (TEE)

В. БИЧЕВИН, Х. КЯЭМБРЕ. ТЕРМОЭКЗОЭМИССИЯ (ТЭЭ) ИОННЫХ КРИСТАЛЛОВ, РЕНТГЕНИЗОВАННЫХ ПРИ ТЕМПЕРАТУРЕ ЖИДКОГО ГЕЛИЯ

(Presented by Ch. Lushchik)

We have observed the TEE from commercial KCl and homemade NaCl:Ag crystals X-rayed at liquid helium temperatures.

The experiments were performed by using a metallic ultrahigh vacuum cryostat [1] equipped with a KT 372 transistor for temperature measurements (accuracy ±1...2 K), a VEU-OT-8M secondary electron



Thermoluminescence (*1*) and thermoexoemission (*2*) glow curves for KCl and NaCl : Ag, X-rayed at liquid helium temperature.

multiplier operated in counting mode for TEE recording, and a FEU-71 photoelectron multiplier as a light emission sensor. The crystal platelets ($\approx 1 \times 5 \times 10$ mm^3) were soldered with an In allov to the cold finger surface. The liquid-He-cooled samples were irradiated with 1 . . . 2 kGy X-ray (W, 60 kV) doses. After X-raying, the He supply was switched off and the TEE and thermoluminescence (TL) were recorded during natural warming (≈ 7 K/min) of the sample.

The simultaneously recorded TEE and TL glow curves are depicted in the Figure. To our knowledge, no TEE has been observed yet from insulators at such low temperatures (cf. [2] for metals). One can see an obvious correlation between TEE and TL peaks (TL peaks near 40 K in KCl and 20 K in NaCl, not resolved in our curves, are well distinguished, e.g. in [3–5]). On the other hand, within the error limits, our TL peaks coincide with those observed by other authors [3–10], who have examined the TL of KCl and NaCl along with thermal annealing of I, α, F, H, and V_k centres. Thus attempting to elucidate the processes leading to the observed TEE, one can rely upon their results and conclusions.

Since in the considered temperature interval the only mobilized entities are the interstitial components of Frenkel defects, we conclude that our TEE is initiated by mobile interstitials, I and H centres.

The following defect reactions [3–10] can plausibly result in TEE (cf. also [11]):

$$I+F \rightarrow R+e^-; \qquad (1.1)$$
$$H+F' \rightarrow R+e^-; \qquad (1.2)$$
$$I+\alpha \rightarrow R+\varepsilon; \quad \varepsilon+E \rightarrow E^{\cdot}+e^-; \qquad (2.1)$$
$$H+F \rightarrow R+\varepsilon; \quad \varepsilon+E \rightarrow E^{\cdot}+e^-. \qquad (2.2)$$

I, H stand for mobile interstitials, F, F', α are the corresponding centres, R — regular lattice, e^- — conduction electron, E — electron centre, $E^{\cdot}$ — ionized E, ε — released energy. If the energy obtained in the recombination act is sufficient, a part of the produced e^- can be ejected from the crystal. Plausibly, the emission is assisted by the electric field induced in the crystal surface layer by X-ray photoemission in the course of excitation. Under equal defect annealing rates one-stage reactions (1.1—2) are more TEE-efficient as compared with the two-stage ones (2.1—2); processes (1.1—2) are more probable at the annealing stages of distant, uncorrelated Frenkel pairs. Our tentative interpretation of the TEE spectra is outlined in the Table (if several reactions are indicated, they are listed in the order of diminishing probability). Some confusions, such as different heating rates and temperature assessment errors, dose dependence of the annealing stages [12], discrepant conclusions of different researchers, etc. aggravate the referring to literature data. We hope to improve the interpretation in the future studies.

Sample	TEE peak	Reaction(s)*
KCl	I	(1.1)′; (2.1)
	II	(1.1)
	III	(1.2); (1.1)″; (2.2)
NaCl : Ag	I	(1.1)
	II	(1.2); (1.1)′

* In the cases (1.1), (1.1)′, and (1.1)″ different initial arrangements of I and F centres in the lattice have been assumed.

To conclude, we have discovered a new kind of recombinational TEE, accompanying the Frenkel defect annealing at low temperatures. Its recombinational nature similárizes it to the well-known TEE at thermal release of self-trapped holes — V_k centres (see, e.g. [13–15]), but it differs from the V_k-emission by the possibility of electron release via one-stage process (1.1—2).

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