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## ПОЛЯРИМЕТРИЯ ГАЛИЛЕЕВЫХ СПУТНИКОВ ЮПИТЕРА ВБЛИЗИ ОППОЗИЦИИ В 2012–2014 ГОДАХ

*Представляются результаты поляриметрических наблюдений галилеевых спутников Юпитера Ио, Европы, Ганимеда и Каллисто, которые проводились в 2012-2014 гг. на 2.6-м телескопе им. Шайна (п. Научный, Крымская астрофизическая обсерватория) и 1-м телескопе Цейсс-1000 (п. Симеиз, Крымская астрофизическая обсерватория) с помощью одноканальных фотометров-поляриметров. Диапазон фазовых углов составлял 0.03° - 3.46°. Диапазон фазовых углов Наши новые наблюдения подтверждают присутствие оппозиционного поляриметрического эффекта для высокоальбедных спутников Ио, Европы, и Ганимеда на углах, меньших 2°. Присутствия поляриметрического оппозиционного эффекта для Каллисто не обнаружено.*

***Ключевые слова:*** *поляризация, спутник, поляриметрический оппозиционный эффект.*

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# THE INFLUENCE OF AN EXTERNAL ELECTRIC FIELD AND UNAXIAL PRESSURE ON THE DIELECTRIC PROPERTIES OF TGS+$Cu^{2+}$ CRYSTALS

*The results of an experimental study of the effect of uniaxial pressure and external electric field on dielectric properties of TGS crystals doped with metallic impurities of $Cu^{2+}$ in the vicinity of the ferroelectric structural phase transition are presented. The obtained results are compared with published data for undoped TGS crystals. The results of experimental measurements shows that for the TGS crystals the uniaxial pressure $\sigma_2$ leads to a decrease in the maximum values of the dielectric constant and reducing the phase transition temperature and external electric fields leads to a decrease in the maximum values of the dielectric constant and increment of the phase transition temperature.*

***Keywords:*** *TGS, external electric field, uniaxial pressure, metal impurities, dielectric constant, ferroelectric crystals.*

**Introduction.** Among the ferroelectric crystals with hydrogen bonds triglycine sulfate $(NH_2CH_2COOH)_3{\cdot}H_2SO_4$ (TGS), despite the complexity of the chemical formula and crystal structure, investigated the most fully. They are ferroelectrics with second order phase transition of "order-disorder" type. The crystal has monoclinic symmetry and belongs to centrosymmetric class 2/m above the Curie temperature $T_C$ = 322 K. Below $T_C$ the mirror plane disappears and the crystal belongs to the polar point group 2 of the monoclinic system.

The most important in understanding the mechanisms of phase transitions in ferroelectric crystals with hydrogen bonds is a study of their behavior under the influence of external factors such as pressure or electric field [1]. In particular, the external pressure is the only way to continuously modify the geometric characteristics of hydrogen bonds, break their equivalence etc., which makes it possible to investigate the role of hydrogen bonding in the mechanisms of the phase transition and dielectric response of crystals.

Significant part of ferroelectrics with hydrogen bonds has piezoelectric properties in the paraelectric phase. Applying the mechanical stress provides an opportunity to examine the piezoelectric interactions in phase transformations and formation of the physical characteristics of crystals [2].

To change the properties of the triglycine sulfate crystals they are doped by metallic or organic impurities.

The aim of this paper is to study the dielectric properties of TGS+$Cu^{2+}$ crystals under the influence of an external electric field and uniaxial pressure. The concentrations of impurities for these crystals are 2%.

**Experimental.** The dielectric constant of the crystals was determined by the results of experimental measurements of the capacitance of samples and was calculated by using the formula for a plane capacitor. The capacitance of samples was directly measured by using an AC bridge LCR E7-12 at a frequency of 1 MHz with a measuring field of 1.25 V/cm.

Samples were made in the form of a parallelepiped, oriented according to the crystallographic axes. At the edge, which are perpendicular to the polar direction, were applied electrical contacts with silver paste. Uniaxial mechanical stress was created by a spring dynamometer and was transferred on sample through a punch with floating heads (fig. 1).

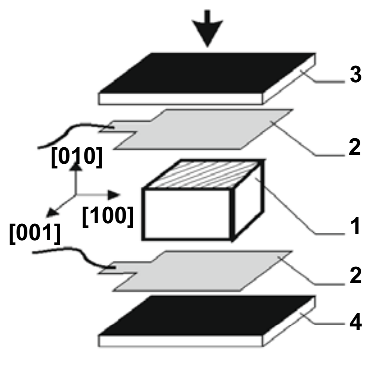


**Fig. 1. Method of the investigations under the influence of uniaxial compression (1 – sample, 2 – cooper foil contacts, 3 – floating head punch, 4 – cell support)**

The accuracy of registration of the uniaxial pressure was ± 5%. The samples were placed in a specially constructed thermostat which allowed to gradually adjust the temperature of sample. The temperature was measured by the copper-constantan thermocouple with an accuracy of ± 0.1 K. To improve heat transfer and to prevent contact with air the sample and thermocouple were filled by silicone oil.

The device for investigating the ferroelectric crystals under uniaxial pressure allows to perform measurements over a wide temperature range (77÷370 K) and efforts (up to 45 kg). Uniaxial pressure was applied along the ferroelectric axis b, which corresponds to the mechanical stress $\sigma_2$ [3].

Fig. 2 shows the temperature dependences of the dielectric constant of studied crystals under the influence of the external electric field.

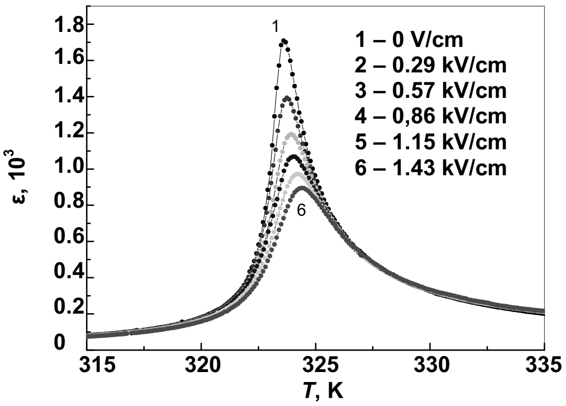


**Fig. 2 Temperature dependences of the dielectric constant of TGS+$Cu^{2+}$ crystals for different values of external electric fields**

Fig. 3 shows the temperature dependences of the dielectric constant of studied crystals under the influence of the uniaxial pressure $\sigma_2$.

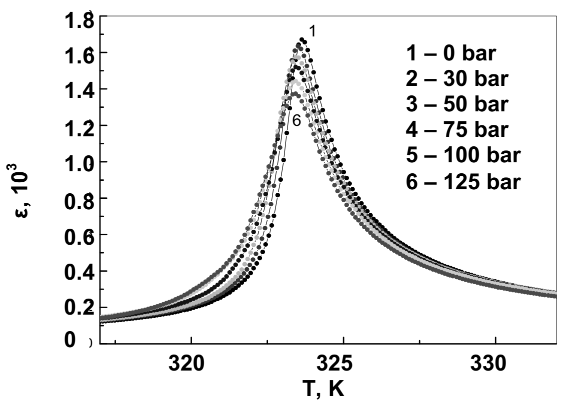


**Fig. 3. Temperature dependences of the dielectric constant of TGS+$Cu^{2+}$ crystals for different values of uniaxial pressure $\sigma_2$**

It can be seen, that the application of mechanical stress and external electric field decreases the maximum value of the dielectric constant.

Fig. 4 shows the field dependences of the maximum temperature of the dielectric constant and the values of this maximum of TGS+$Cu^{2+}$ crystals.

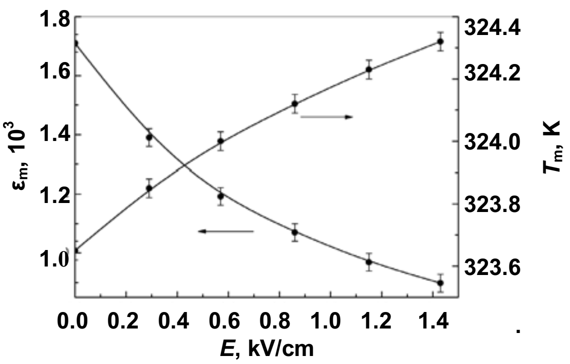


**Fig. 4. The field dependences of the maximum temperature of the dielectric constant and the values of this maximum of TGS+$Cu^{2+}$ crystals**

Fig. 5 shows the phase $\sigma_2$,T-diagrams of TGS+$Cu^{2+}$ crystals. To construct the phase diagrams the extrapolating of the inverse temperature dependence of the dielectric constant to zero in the paraelectric phase was performed [2].

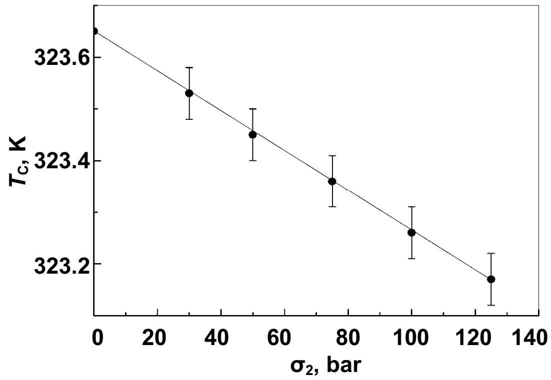


**Fig. 5. The phase $\sigma_2$,T-diagrams of TGS+$Cu^{2+}$ crystals**

The temperature of the maximum of the dielectric constant increases under the influence of an external electric field whereas it – decreases under the influence of uniaxial pressure.

It was shown that the increase in the atomic mass of doped impurities leads to the increase in the phase transition temperature. Thus, for TGS and TGS+$Cu^{2+}$ crystals it was, respectively, 321,9 K and 323,6 K.

The pressure coefficients of the shift the phase transition temperature for Cu-doped TGS crystals is equal to – 5.3 K/kbar. The displacement of the phase transition temperature under the influence of uniaxial pressure along the ferroelectric axis of doped crystals was less than for undoped ones.

This effect can be accounted for by the existence of internal electric fields in doped crystals, the value of which is determined by the presence of impurities [1, 4]. The nature of such internal fields has a relaxing character, and the presence of such internal field, along with the changes of the temperature maximum of dielectric constant, leads to the blurring of ε(T) dependencies.

**Conclusions.**

1. Established the reducing of displacement of the phase transition temperature of doped TGS crystals, due to the existence of internal electric fields, the value of which is determined by the presence of impurities ($Cu^{2+}$).
2. The phase $\sigma_2$,T-diagrams are constructed.
3. For the TGS+$Cu^{2+}$ crystals the uniaxial pressure $\sigma_2$ leads to a decrease in the maximum values of the dielectric constant and reducing the phase transition temperature with a coefficient of $dT_c/d\sigma_2$ = – 5.3 K/kbar.
4. Increasing the atomic mass of dopants leads to an increase in the phase transition temperature. Thus, for TGS and TGS+$Cu^{2+}$ crystals it was, respectively, 321.9 K and 323.6 K.

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## ВПЛИВ ЗОВНІШНЬОГО ЕЛЕКТРИЧНОГО ПОЛЯ ТА ОДНОВІСНОГО ТИСКУ НА ДІЕЛЕКТРИЧНІ ВЛАСТИВОСТІ КРИСТАЛІВ TGS+$Cu^{2+}$

*Наведено результати експериментального дослідження впливу одновісного тиску та зовнішнього електричного поля на діелектричні властивості кристалів ТГС, легованих металічними домішками $Cu^{2+}$, в околі структурного сегнетоелектричного фазового переходу. Отримані результати порівнюються з літературними даними для нелегованого домішками кристалу ТГС. Результати експериментальних вимірювань показали, що для кристалів ТГС+$Cu^{2+}$ одновісний тиск $\sigma_2$ приводить до зменшення максимальних значень діелектричної проникності та зменшення температури фазового переходу, а зовнішнє електричне поле призводить до зменшення максимального значення діелектричної проникності і зростання температури фазового переходу.*

***Ключові слова:*** *ТГС, зовнішнє електричне поле, одновісний тиск, металічні домішки, діелектрична проникність, сегнетоелектрики.*

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## ВЛИЯНИЕ ВНЕШНЕГО ЭЛЕКТРИЧЕСКОГО ПОЛЯ И ОДНООСНОГО ДАВЛЕНИЯ НА ДИЭЛЕКТРИЧЕСКИЕ СВОЙСТВА КРИСТАЛЛОВ TGS+$Cu^{2+}$

*Приведены результаты экспериментального исследования влияния одноосного давления и внешнего электрического поля на диэлектрические свойства кристаллов ТГС, легированных металлическими примесями $Cu^{2+}$, в окрестности структурного сегнетоэлектрического фазового перехода. Полученные результаты сравниваются с литературными данными для нелегированного примесями кристалла ТГС. Результаты экспериментальных измерений показали, что для кристаллов ТГС+$Cu^{2+}$ одноосное давление $\sigma_2$ приводит к уменьшению максимальных значений диэлектрической проницаемости и уменьшению температуры фазового перехода а внешнее электрическое поле приводит к уменьшению максимального значения диэлектрической проницаемости и увеличению температуры фазового перехода.*

***Ключевые слова:*** *ТГС, внешнее электрическое поле, одноосное давление, металлические примеси, диэлектрическая проницаемость, сегнетоэлектрики.*

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## LUMINESCENT PROPERTIES OF ORGANIC DYES IN POLYMERS PEPK AND PVE

*Sandwich-structures for the electroluminescence investigation were produced with the method of the organic dye applying to the glass substrate surface covered with ITO with spin-coating. Aluminium contacts were evaporated in the vacuum chamber. Samples for the photoluminescence investigation were prodused simultaneously. The dependence of the change in position of the maxima of the photoluminescence spectra on the dye content and the matrix polymer type were investigated. Current-voltage characteristic of the produced structures were obtained and the dependence of integral electroluminescence intensity on the voltage on the sample was determined.*

***Key words:*** *organic dye, PEPK, PVE, ITO, sandwich-structure, OLED, photoluminescence, electroluminescence, PPV.*

Light emitting structures based on organic materials are widely used all over the world. In comparing to liquid crystal displays (LCD) OLED-displays need any external highlight, have a large viewing angle and wide working temperature range. OLED-technologies permit flexible displays creation. One of the fundamental materials for organic light emitting structure fabrication is PPV. The aim of this work is investigation of polymers PEPK and PVE, doped with an organic dye, as an alternative material for organic light emitting structures fabrication.

Samples for the electroluminescence investigation were made as a sandwich-structure (Fig. 1). On the glass substrate with ITO-layer sequentially were applied layers of PEDOT:PSS and polymer, doped with an organic dye using spin coating [2]. Chosen PEDOT:PSS is modified and has optimal conductivity and capacity [3]. PEDOT:PSS decreases ITO surface irregularity and enhance hole injection [4].

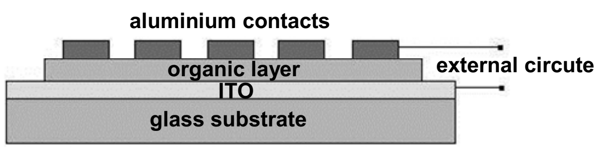


**Fig. 1. Sandwich-structure**

As an active layer we used polymers PEPK and PVE, doped with the organic dye DCM (1% and 10%). Structural formulas of the dyes DCM and №1 are shown on figures 2 and 3 respectively. Aluminium electrodes were deposited through the mask on the polymer layer.

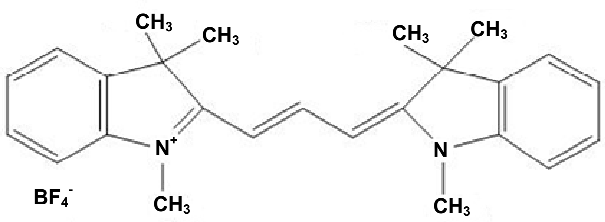


**Fig. 2. Structural formula of the dye №1**

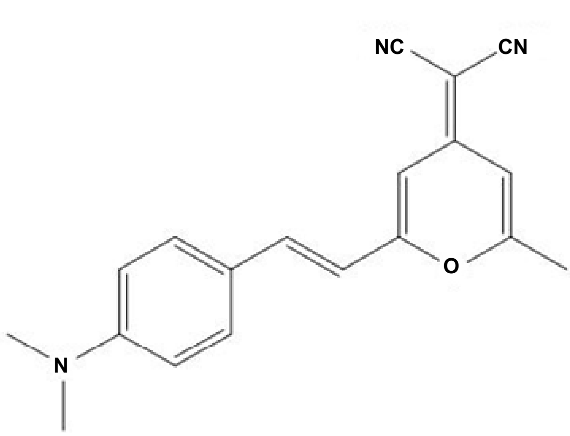


**Fig. 3. Structural formula of the dye DCM**