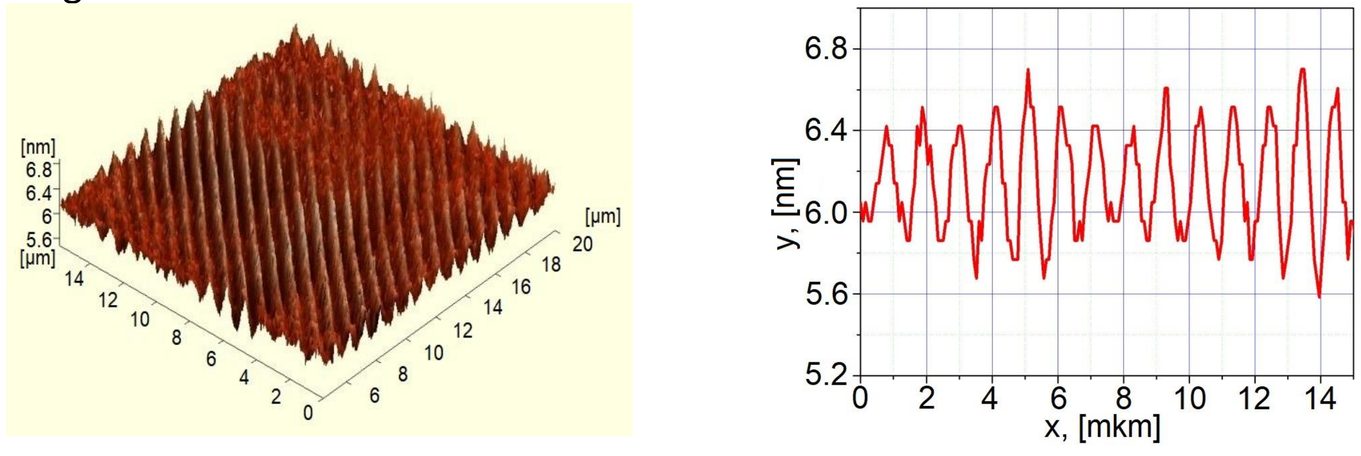
Peculiarities of ferroelastoelectric domain structure and nanocrystals' growth on the surface of $[(CH_3)_2CHNH_3]_4Cd_3Cl_{10}$ crystal

Chornii Yu., Kapustianyk V., Eliyashevskyy Yu., Serkiz R.

e-mail: ychornii@gmail.com

Department of Physics, Ivan Franko National University of Lviv, Dragomanova str. 50, 79005 Lviv, Ukraine.

This work is devoted to study of ferroelastoelectric domain structure and peculiarities of nano- and microcrystals growth on the surface of $[(CH_3)_2CHNH_3]_4Cd_3Cl_{10}$ (IPACC) crystals. The domains in the ferroelastoelectric phase lying below 294 K were visualized using AFM.



a) b)

Fig. 1. 3D presentation (a) and profile (b) of the surface of the freshly cleaved sample of b-cut of IPACC crystal visualized at T=280 K by AFM.

In the contact mode we observed a regular pattern of the parallel strips with an average thickness of nearly 1 µm that would be considered as domains. Moreover, the surface of the crystal was found to be modulated with an amplitude close to 1 nm. The neighboring domains should differ by their optical characteristics, first of all, by the refractive indices due to a different sign of the electrooptic effect. Due to this IPACC crystals would be used as a diffraction grating with a period close to 1 µm.

It was shown that the surface morphology of IPACC crystals kept for a long time (from one up to twelve months) in the open air with a high humidity undergoes the considerable changes in comparison with the freshly cleaved samples. The samples are characterized by growth of the nanocrystals on the first stage and the larger microcrystals on the next stages of the sample aging. Another types of the elements observed on the surface were the nano- or microrods. The model describing the peculiarities of surface morphology and domain structure modification arising in the process of aging was proposed.

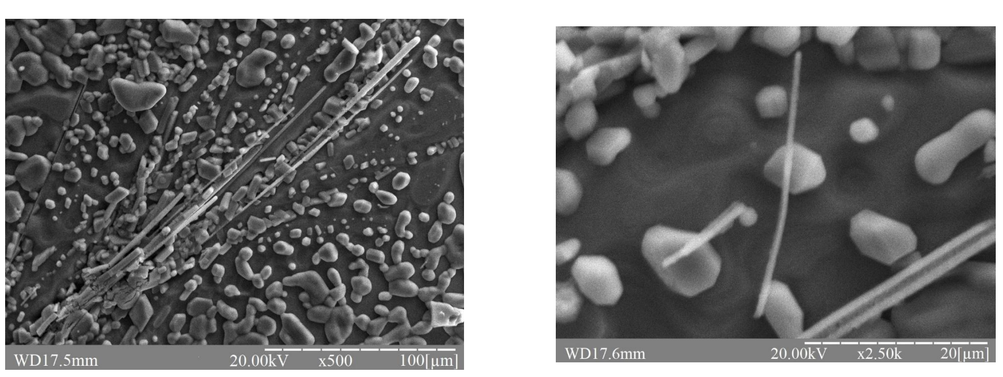


Fig. 2. SEM images of IPACC of various region of the aged crystal surface presented in different scale.

It is interesting to note that no similar processes of aging were detected in IPACCC crystals doped with copper [1]. Due to this such materials look more suitable for the mentioned practical applications.

Conclusions

Using the methods of AFM microscopy we confirmed that IPACC crystals are characterized by the ferroelastoelectric domain structure similar to those in the same crystal doped with copper (IPACCC). On the other hand, one can suggest that there was observed a considerable difference in the both compared crystals. The boundaries of smaller domains were found to be turned in respect to the boundaries of the larger domains by the angle a little less than 100^o. On the basis of the performed investigations of different IPACC samples one can conclude that the initial crystals possess only a one type of domains. It seems that doping with copper would considerably change the parameters of the ferroelastoelectric domain structure.

The surface morphology of IPACC crystals kept for a long time (from one up to twelve months) in the open air undergoes the considerable changes in comparison with the freshly cleaved samples. The samples are characterized by growth of the nanocrystals on the first stage and larger microcrystals on the next stages of the sample aging.At the enough high humidity of the environment the atmospheric water condensed on the bulk crystal surface causes the alternating process of bulk crystal dissolving and nano- or microcrystal growth. By their shape these nano- or microcrystals look very similar to the bulk crystal habit.

Another type of the elements observed on the surface would be considered as nano- or microrods. According to the qualitative data of the EDX analysis they would contain oxygen that may be connected with formation of the crystal hydrate compound.

The water condensed from atmosphere on the crystal surface causes also a specific etching of the sample with a different rate for the neighboring domains. One can suggest that this process depends on the sign of corresponding piezoelectric coefficient or the sign of the polarization caused be the shear mechanical stress arising at the process of crystal cleavage.

[1] *V. Kapustianyk, Z. Czapla, V. Rudyk, Yu. Eliyashevskyy, P. Yonak, S. Sveleba.* Domain structure and birefringent properties of $[(CH_3)_2CHNH_3]_4Cd_3Cl_{10}$:Cu crystals in the region of their phase transitions // Ferroelectrics.-2019.-**540**, N 1.-P. 212-221.

Acknowledgement This work was supported by the National Research Foundation of Ukraine in the framework of the project 2020.02/0130 "Multifunctional organic-inorganic magnetoelectric, photovoltaic and scintillation materials" (Reg. No 0120U104913).