# electrical properties of $PbMoO_4$ single crystals

**T.M.Bochkova[1]*, M.P. Trubitsyn[1], M.D. Volnianskii[1], D.M. Volnyanskii[2]**

*[1] Institute for Energy Efficient Technologies and Materials Sciences, Oles Honchar Dnipro National University, prosp. Gagarina 72, Dnipro, 49010, Ukraine;*

*[2] Ukrainian State University of Science and Technologies, Lazaryan str. 2, 49010 Dnipro, Ukraine*

**E-mail: tbochkova@meta.ua**

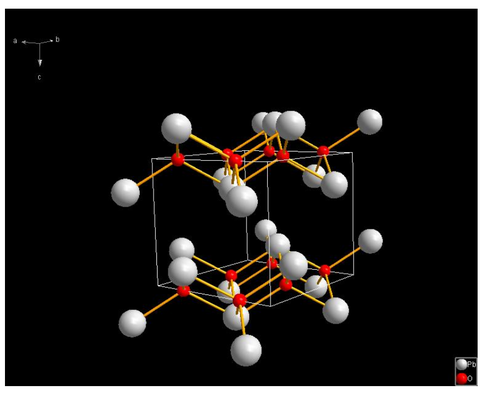
## Introduction

$PbMoO_4$ crystals are widely used in modern electronics as multifunctional materials. The main areas of applications are acousto-optics, laser technology and cryogenic scintillation systems for detecting rare events in physics of elementary particles. These applications require large-sized crystals of good quality. However, $PbMoO_4$ crystals grown from a melt on a seed, as a rule, contain characteristic structural imperfections. Among them there are nanometer-sized clusters, including intrinsic point defects and impurities, photoinduced complexes based on anionic $MoO_4$ groups with trapped photoelectrons, inclusions of foreign phases. Such defects have a strong effect on the electrical and optical properties of crystals. In this work, we study the effect of variations of the initial mixture composition and UV irradiation on polarization and charge transfer processes in $PbMoO_4$ single crystals.

## Experimental details

The single crystals of $PbMoO_4$ were grown from the melt by conventional Czochralski technique in air by using platinum crucibles. The charge was prepared by solid phase synthesis at 925-975 K for 2 hours from $MoO_3$ and PbO of α - or β - modifications of "high purity" grade. The reagents were taken both in a stoichiometric ratio and with excess of 0,5 mol% of $MoO_3$. The crystals grown in the direction deviated by 30° from *a*-axis in (001) plane were free from gas bubbles and cracks. The main planes of the samples with dimensions 5×5×1 $mm^3$ were cut perpendicular to the growth axis. The main faces of the samples were irradiated using light-emitting diode with radiation wavelength λ=365–370 nm for 30 – 60 minutes. Then platinum electrodes were deposited by cathode sputtering. Permittivity ε and conductivity σ were measured in AC field by the bridge method at fixed frequency (f=1 kHz) in the temperature interval 290–700 K.

## Results and discussion



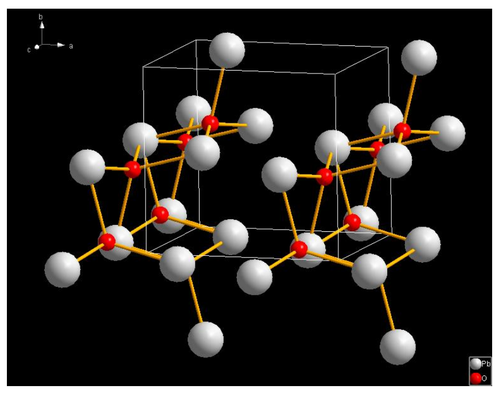


Fig.1. PbO can exist in two polymorphic forms. This is an α-modification (lead litharge), which has a red color and belongs to the tetragonal syngony (symmetry space group *P* 4/*nmm*, *Z*=4, unit cell parameters: *a*=0.3976 nm; *c*=0.5023 nm, figure on the left). And β-modification (massicot), the crystals of which are yellow in color and are characterized by rhombic symmetry (space group *P bcm*, *Z*=2, unit cell parameters: *a*=0.5489 nm; *b*=0.4755 nm; *c*=0.5891 nm, figure on the right).

In this work, we have shown that choice of PbO crystal modification type for charge preparation and the excess amount of $MoO_3$ affect the processes of polarization and charge transfer in $PbMoO_4$ crystals. The use of the α-modification of PbO as the initial reagent increases AC electrical conductivity (f = 1 kHz) in a wide temperature range. Preliminary illumination of the samples with UV clight leads to the appearance of a maximuma in the temperature dependences of the permittivity and conductivity. The introduction of excess of molybdenum oxide in the amount of 0.5 mol% into the mixture for growing $PbMoO_4$ crystals gives the similar results.

Within the framework of the hopping conductivity model, we suppose that the observed changes in electrical properties are associated with a redistribution of the density of localized states in the bandgap of $PbMoO_4$ crystals, caused by the appearance of the structural and the photoinduced nanometer-sized defects in the crystal lattice.

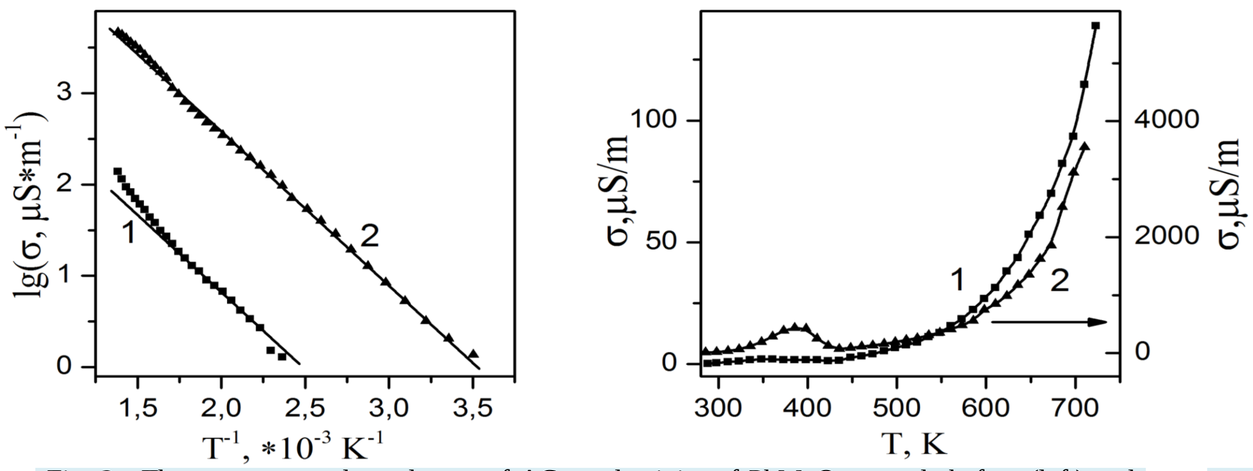



Fig. 2. The temperature dependences of AC conductivity of $PbMoO_4$ crystals before (left) and after UV irradiation (right): 1 – crystals were grown using β – PbO; 2 - crystals were grown using α – PbO.

Fig. 3. Permittivity dependencies ε(*T*) for $PbMoO_4$ crystals of stoichiometric composition: 1 – crystals were grown using β – PbO; 2 - crystals were grown using α – PbO. The measurements were carried out after irradiation of the samples with UV light.

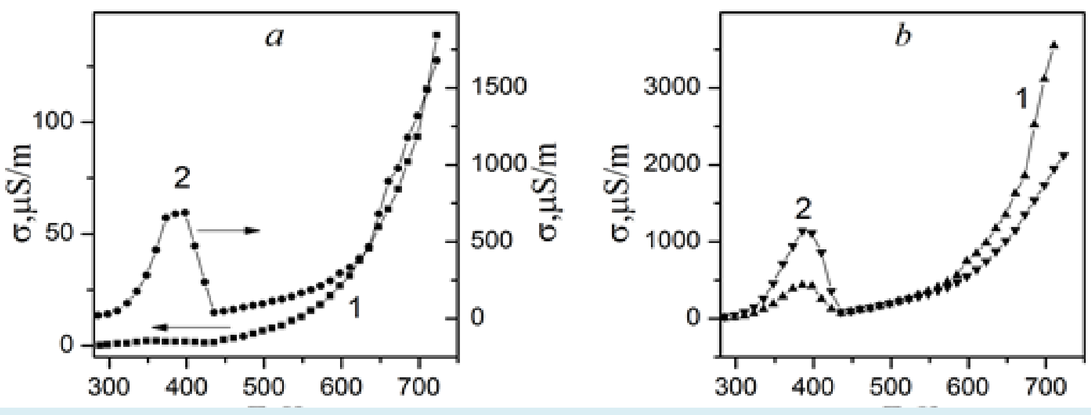



Fig.4. The temperature dependence of AC conductivity (f=1 kHz) of pre-illuminated with UV light $PbMoO_4$ crystals: the crystals grown using β-modification (a) and α-modification of PbO (b) (1 – the charge of stoichiometric composition, 2 – the charge with 0.5 mol% $MoO_3$ excess).

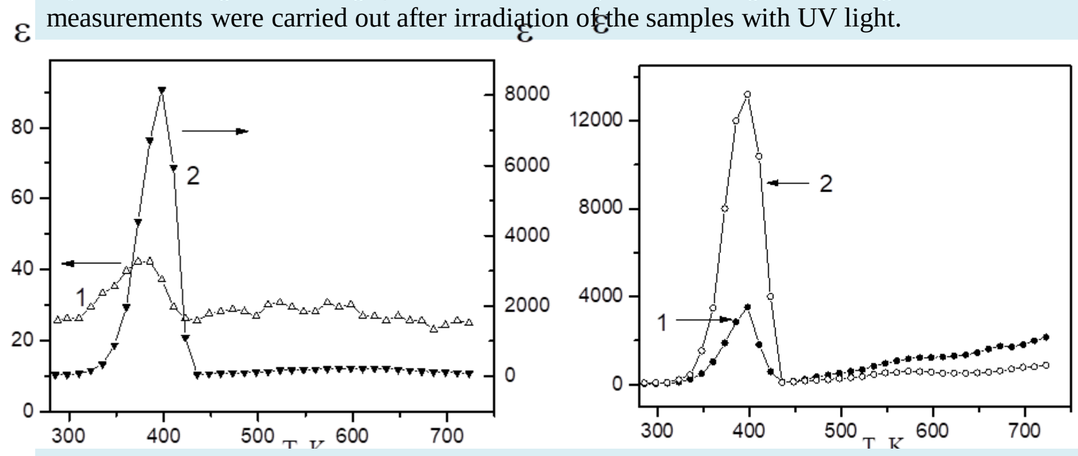



Fig.5. Permittivity dependencies ε(*T*) for $PbMoO_4$ crystals grown using β -PbO (left) and α – PbO (right): 1 – stoichiometric composition, 2 – composition with excess of 0,5 mol % $MoO_3$. The measurements were carried out after irradiation of the samples with UV light.