Comparative study of the luminescence properties of macro- and nanocrystalline MgO using synchrotron radiation.

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Investigations of luminescent properties of magnesium oxide (MgO) have been carried for about 50 years already. Nevertheless, nowadays, this material is still interesting object for investigation because MgO is a “model-crystal” and allows analyzing of well-defined environment. MgO a very important wide band gap (Eg=7.8 eV) insulator material, which has been attracting both fundamental and application studies. Its electronic, optical and radiation properties have been investigated in details and there are many studies of the luminescence of nominally pure and impurity-doped MgO crystals after exposure to a variety of ionizing radiation, including UV-light, X-ray, gamma, electron or neutron irradiation. Spectral analysis of this emission shows broad features in the blue, orange and red with the relative emission intensity in each regions being strongly dependent on temperature and radiation conditions. The goal of the present study was to compare the luminescent properties of nanocrystalline MgO which was prepared by the extractive-pyrolytic method with macromolecular powder analogues and a single crystal. Special attention was paid to VUV spectral range, which is not reachable with commonly used lamp and laser sources.

Comparative analysis of the luminescent properties of nanocrystalline MgO with macromolecular powder analogues and a single crystal has been performed under excitation by pulsed VUV synchrotron radiation. The MgO nanopowders have been prepared by the extractive-pyrolytic method. The X-ray diffraction measurements have been performed in order to investigate the crystalline structure and to provide an average crystallite size of nanoparticles (10-15 nm). Single crystals of MgO were grown by the arc-fusion method at the Institute of Physics, Tartu. The luminescence emission and excitation measurements were carried out under pulsed synchrotron radiation emitted from DORIS III storage ring on the SUPERLUMI station at HASYLAB [1]. This set-up is the most powerful and fruitful technique for investigation of optical and luminescence properties in wide band gap materials [2-6] as well as semiconductor nanocrystals [7].

Fig.1. Luminescence spectra of the MgO crystal, commercial macropowder and nanoparticle samples under excitation 200 nm (6.2 eV).

Fig.2. Excitation spectra of the emission λem=420 nm.
In the Fig.1 the room temperature luminescence spectra of a MgO crystal, commercial macropowder and nanoparticle samples under excitation at 200 nm (6.2 eV) are presented. The emission band in the 2.9-3.0 eV region has almost Gaussian shape with the maximum at 2.93; 2.93 and 3.01 eV and half-width 0.78; 0.86 and 0.99 eV for single crystal, macropowder and nanoparticle samples, respectively. In addition, in the case of MgO single crystal, strong well-known Cr$^{3+}$ band at about 700 nm was also observed.

Fig. 2 displays the excitation luminescence spectra for all these three samples measured at 2.95 eV (420 nm) in spectral range 4.5 -10.0 eV. Two definite conclusions can be drawn here, namely:

(a) the excitation spectra for crystal and commercial macropowder samples have maximum at almost the same energy (at about 5.75 eV), while the appropriate peak for nanoparticle samples reveals blue shift at about 0.3 eV, which could be connected with the nano-size particles of the sample.

(b) the excitation spectra for both macro- and nano-particle samples show the clear shoulder at about 5.0 eV, where the both F and F$^-$ have their optical absorption with peak essentially at the same energy of ~ 5.0 eV, while such feature is absent at all in the case of single crystals.

The details of this study have been summarized and accepted for publication in 2013 in [8].

References

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