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Effect of Plasticity-Induced Defects on Optoelectronic Properties of MgO

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It has been found that some of metal oxides, especially MgO, coated on cathode materials, effectively increase their cycle reversibility. Furthemore, some of nanocrystalline thin films, subsequently coated by MgO, exhibit excellent structural stability and electrochemical performance [1]. It seems worthwhile., therefore, to investigate an effect of plastic nano-deformation on optoelectronic properties of MgO. In this investigation an attempt has been made to determine the smallest value of load at contact damage in (001) MgO crystal that could change its optoelectronic properties. For this purpose complex method [2] including nanoindentation, atomic force microscopy (AFM), color cathodoluminescence (CL) in scanning electron microscopy (CCL-SEM), CL spectroscopy (CLS) and CL-profiling (CLP), was applied. Luminescent centers attributed to dislocation-vacancies ensembles were induced in MgO crystals of 99.99% purity by using nanoindentations, .which have been made at different peak loads, ranging from 1 mN up to 120 mN. By using analysis of the load-versus–displacement nucleation of dislocation at 0.5 mN of critical load has been revealed. The topography of investigated surface has been displayed by using the AFM, as shown in Fig.1. It has been also shown that plasticity-induced defects surrounding residuals imprint of nanoindentations, which had been made at peak loads beyond 10 mN, do luminescence fairly strongly. For all these nanoindentations, spatial distributions of luminescent centers, .providing enhanced CL at visible spectral band, have been recorded. These distributions had been detected at information depth of CL-signal of 2 μm under the indented surface and were displayed in form of the CLP and CCL-SEM maps. Some of them are shown in Fig. 2. Besides, by using the CLS, local CL spectra have been recorded from the plastic zones surrounding the residual imprints of the nanoindentations. These spectra reveal enhancement of panchromatic CL in two main spectral bands centered at λ=470 nm and λ- 480 nm. These luminescent bands can be attributed to the positively charged and the neutral oxygen vacancies, referred to the F+- and F-centers in MgO, respectively. Obtained dependence of optoelectronic properties on the plasticity-induced defects can be used for revealing plastic deformation of MgO thin films on the nanoscale.

References:

1. Y. Wang, Y. Zhang, H. Liu, S. Yu and Q. Qin: Nanocrystalline NiO thin film anode with MgO coating for Li-ion batteries, Electrochemical Acta, 48, pp. 4253–4259 (2003).
2. T.A. Nazarova, M.V. Nazarov, G. V. Saparin, et al: Investigation of Cathodoluminescence from Nanoindentations on Magnesium Oxide Single Crystals, SURFACE, 2, pp. 58-68 (2004) (on Russian)

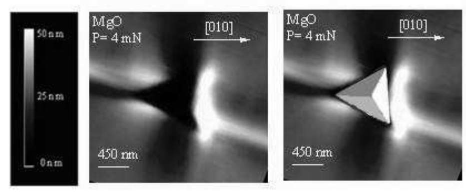

Fig.1. AFM images of nanoindentation made at peak load 4 mN. The shape and dimension of the residual imprint, which has been made with diamond Berkovich indenter, is shown on the right frame

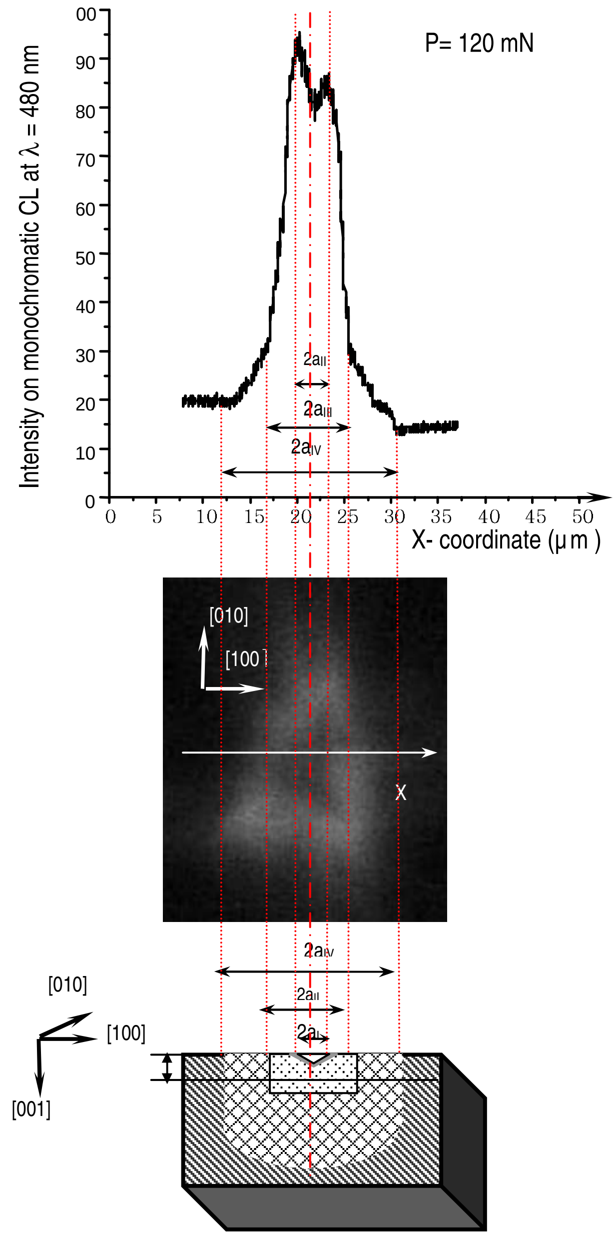

Fig.2. Profile of monochromatic CL at wavelength λ=480nm corresponding to distribution of concentration of F-centre in MgO and recorded from the nanoindentation, which has been made at P=120 mN; panchromatic CL-SEM map recorded in the wavelength range of 400 to 750 nm in the same nanoindentation; schematic representation of plastic zones in (010) section through the Berkovich nanoindentation.