Zn NANOPARTICLES FORMATION BY UV LASER RADIATION IN ZnO CRYSTAL

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Abstract

Zn nanoparticles were grown at the surface of ZnO single crystal by UV laser radiation. As a result "black" ZnO was formed. The formation of Zn nanoparticles by the laser is explained by Thermogradient effect. According to the effect, the gradient of temperature induced by nanosecond laser radiation leads to generation of Zn interstitial atoms and to their concentration at the irradiated surface of the ZnO crystal. This was proved by huge increase of electrical conductivity up to 250 times with the increase of laser radiation intensity. Moreover, the topography change of the irradiated surface was not observed till laser intensity I_{max} = 290 MW/cm^2. The increase of Zn_i atoms concentration at the irradiated surface of the sample at certain concentration leads to conglomeration of Zn_i atoms forming Zn nanoparticles with size up to 50nm.

Key words: *Zn nanoparticles, ZnO crystal, UV laser*

The research of ZnO has been at high interest for quite a long time due to its unique optical, piezoelectric and magnetic properties, as well as potential applications such as: light emitting diodes, near-UV or UV laser diodes [1] and solar cells [2]. The aim of the present work is to study the possibility of formation of Zn nanoparticles by UV laser on a surface of ZnO crystal.

Hydrothermally grown ZnO single crystals were irradiated by forth harmonic of pulsed Nd:YAG laser (Ekspla NL301G) with the following parameters: wavelength $\lambda = 266$ nm, pulse duration $\tau = 3$ ns, and laser intensity up to I_{max} = 290 MW/cm^2. The measurements of surface topography and electrical conductivity mapping were performed by atomic force microscopy (AFM). The measurements of surface morphology were performed by scanning electron microscopy (SEM).

Morphology of ZnO crystal surface irradiated by Nd:YAG laser at intensity 290 MW/cm^2 is shown in Fig.1. It can be seen, that nanoparticles with size up to 50 nm are formed. A similar result on formation of Zn nanoparticles on the irradiated surface was observed [3]. The authors this effect explain by evaporation of oxygen atoms from the irradiated surface due to melting of the crystal.

The formation mechanism of Zn nanoparticles by the laser is explained by Thermogradient effect [4]. According to the effect, laser radiation leads to generation and redistribution of point defects. In our case, the generation of Zn_i - V_{Zn} pairs takes place. It is explained by low formation

energy of these defects in ZnO crystal in comparison to other native point defects. Therefore, it is more likely that during irradiation V_{Zn} and Zn_i are formed. The gradient of temperature field induced by laser radiation leads to redistribution of the point defects and the drift of Zn_i atoms to the irradiated surface of the sample takes place. This was proved by huge increase of electrical conductivity up to 250 times. Moreover, the topography change was not observed till laser intensity 290 MW/cm^2. The increase of Zn_i atoms' concentration at the irradiated surface of the sample at certain concentration leads to the conglomeration Zn_i atoms forming Zn nanoparticles.

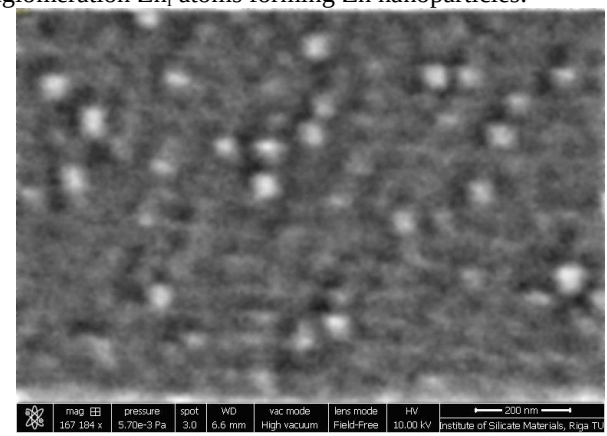

Fig. 1. Morphology of ZnO crystal irradiated by Nd:YAG laser at intensity 290 MW/cm^2.

Conclusions

1. Formation of Zn nanoparticles in ZnO crystal with diameter up to 50 nm after irradiation by laser with intensity 290 MW/cm^2 leads to black ZnO formation.
2. Increase of conductivity up to 250 times is explained by generation and concentration of Zn interstitial atoms at the surface of ZnO crystal irradiated by Nd:YAG laser.

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