Imaging of defects in zinc oxide by spectrally resolved two-photon fluorescence microscopy

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In this paper, we present a method for three-dimensional intrinsic defect imaging in zinc oxide (ZnO) by spectrally resolved two-photon fluorescence microscopy. Tightly focused light beam radiated by titanium-sapphire laser is used to obtain two-photon excitation of selected area of ZnO sample. Photoluminescence intensity of a specific spectral range is selected by optical band pass filters and measured by photomultiplier tube. Reconstruction of specimen image is done by scanning the volume of interest by piezoelectric positioning stage and measuring the spectrally resolved photoluminescence intensity at each point. The method was used to observe intrinsic defects in ZnO nanorods sample containing of nanparticles of length in range of 2.5-3.5µm and diameter in range of 0.3-0.5µm. Fig.1.c) shows undefected ZnO nanorods filtered at 390nm 1.d) oxygen vacancies V_0 at 531nm and 1.e) zinc antisites O_{Zn} At 470nm. Spectral ranges were determined from measurements of fluorescence emission spectra and identified basing on literature [1][2].

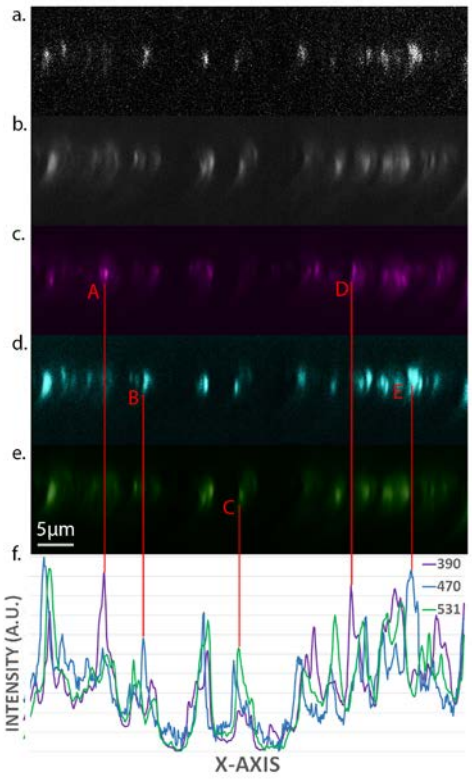

Fig.1. Spectrally resolved two-photon fluorescence X-Z profile image of ZnO nanorods sample a.) filtered for zinc antisites O_{Zn} b.) filtered for oxygen vacancies V_o c.) filtered for undefected ZnO d.) image of zinc antisites O_{Zn} obtained from averaging 40 single-pass images e.) image of oxygen vacancies V_o obtained from averaging 10 single-pass images f.) Normalized and contrast adjusted profiles of images d-f

Our method was proven to be effective in volume imaging of mechanical as well as intrinsic defects of ZnO. The resolution in x- and y-axis is estimated according to literature at 335nm and in z-axis at 1550nm. Method can be used for quality control of preprocessed semiconductors in search for mechanical impurities as well as determining the content of intrinsic defects at any stage of production of semiconductor devices. Other methods of volume defect identification, like XRD, provide information only about existence of various defects, without the ability to image them. Imaging of those defects will help in better understanding of their source and propagation, and might lead to significant improvements in suppressing the formation of impurities during processing of semiconductors.

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2. Cao B, Cai W, Zeng H. Appl Phys Lett 2006, 88:161101.