Three-dimensional imaging of the gallium doped zinc selenide by two-photon fluorescence microscopy

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In this paper, we present two-photon three-dimensional imaging of ion beam deposited gallium ion (Ga^+) doping in zinc selenide (ZnSe) crystal. Tightly focused light beam radiated by titanium-sapphire laser is used to excite two-photon fluorescence of selected point of ZnSe sample. Image of the doped volume is obtained by scanning the area of interest with piezoelectric stage. The excited photoluminescence intensity from a single point is registered as a pixel of the final image. The method was used to measure the depth and concentration of dopants deposited under changing acceleration voltage and ion dose.

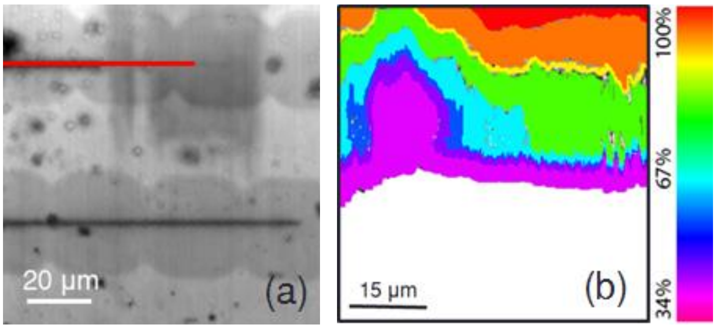

Fig. 1. (a) Two-photon image of the doped area of ZnSe crystal, focused at the depth of 21.4 μm (b) intensity distribution of the cross-sectional image obtained along the red marked line.

The obtained images are presented in Fig. 1. Fig. 1(a) shows the doped area imaged at the depth of 21.4 μm from the surface. As can be noticed, the doped area is clearly distinguishable by a significant decrease of photoluminescence. Fig. 1(b) shows the cross-section image of the doped area, along the red marker in Fig. 1(a). As can be noticed, decreasing the ion dose (from 1.0 $nC/\mu m^2$ to 0.9 $nC/\mu m^2$) lead to over 30% increase of the photoluminescence. The improvement of two-photon fluorescence is due to increased concentration of cell units of ZnSe crystalline structure [1], highly susceptible to two-photon excitation. The dependence of the depth of dopant concentration on the acceleration was also studied. Under the dose of 1.0 $nC/\mu m^2$ and 15kV acceleration voltage the depth of highly doped volume was 28.0 μm. Decrease of the voltage to 10 kV resulted in 24.4 μm depth. Below these depth limits, diffused concentration of the dopants was observed.

Our method was proven to be effective in volume imaging of doping distribution in zinc selenide monocrystals. Presented results confirm that the depth of the doped volume depends on the acceleration voltage and the concentration depends on the ion dosage. Other methods of mapping of dopant concentration are limited to the surface of the sample [2]. Volume imaging provides new possibilities for design and quality control of the semiconductor devices.

1 B Hu, G Karczewski, H Luo, N Samarth, and JK Furdyna, Physical Review B **47** (15), 9641 (1993).

2 Martin R Castell, David A Muller, and Paul M Voyles, Nature materials **2** (3), 129 (2003).