

High resolution Thick ZnO Nanowires in AAO Template for Hard X-Ray Imaging Applications

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High spatial resolution, fast decay time and high detection efficiency are the main parameters of a scintillator for X-Ray imaging applications. Recently, ZnO microrod scintillators with thickness of around 10 μm , electrodeposited in anodizing aluminum oxide (AAO) template [1] and polycarbonate [2] membranes have been used as a position sensitive soft X-ray imagers. In this structures, each microrod surrounded by a light reflective membrane acts as a light guide which conduct the generated photon in each array to photodetector separately. Although, the ZnO microrod fabricated by the electrodeposition method has spatial resolution less than 2 μm , but it's quantum efficiency isn't enough high for hard X-Ray applications. The small length of ZnO microrods in electrodeposition method is a limiting factor related to the properties of ZnO as nonconductive surface which decreases the electrical current during the electrodeposition. But, the methods based on vacuum system are appropriate to overcome this problem by filling the overall height of the channel [3]. In this work, a AAO template with 60 μm thickness, hole diameter 200 nm and inter pore distance of 283 nm (Whatman Company) was filled with ZnO microrod by vacuuming method. The AAO template impregnation was performed by immersing the template in the saturated Zn (NO₃)₂.6H₂O under 150 mbar vacuum conditions for 30 min and then transferred into oven (60 oC for 24 hour). Finally, in order to crystallize the ZnO material, the samples were annealed in air at 500 oC for 3 h (heating rate of 10 oC min⁻¹). The samples were characterized by SEM, EDS, XRD and Photo Luminescence (PL) spectroscopy. The data analysis of SEM images and XRD pattern show that the AAO channels are filled with 40 μm ZnO. The PL spectrum of the sample excited by 250 nm laser reveals a strong and very weak PL emission band at 400 nm and 750 nm, respectively. Annealing of the defects at 500 oC is the source of strong PL related to excitonic emission.

The detection efficiency of 67 ZnO microarrays in AAO template for different thicknesses and X-ray energies was simulated by GEANT4. The results show that for the 15 keV and 20 keV X-rays, the detection efficiency of 30 μm ZnO microarray in 60 μm AAO membrane is 31.34% and 18.97%, respectively. The 60 μm thickness of ZnO microarray at the same energies has detection efficiency of 44.22% and 30.43%, respectively. The experimental and simulation results demonstrated that the vertically aligned ZnO microrod arrays in AAO template could be a good candidate for high spatial resolution hard x-ray medical imaging applications.

References:

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