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Characterizing some detection properties of Zinc Oxide nanowires in Anodic Aluminium Oxide membrane, as a novel high spatial resolution X-ray imager

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The novel idea of using scintillator nanowires in polycarbonate membrane as a high spatial resolution X-ray imager is proposed by our group at Amirkabir University of Technology [1-3]. In this work, a new generation of nano scintillator X-ray imagers based on ZnO nanowires in Anodized Aluminum Oxide (AAO) nanoporous template is characterized. This characterization consists of simulation, radiation test of the detector by soft X-ray and analyzing the experimental spectrums for extracting the detection properties of ZnO nanowires.
For this purpose, the optical response of crystalline ZnO nanowire arrays in porous AAO template irradiated by low energy X-ray is simulated by the Geant4 Monte Carlo code. The results show that for 10 keV X-ray photons, by considering the light guiding properties of zinc oxide inside the AAO template and suitable selection of detector thickness and pore diameter, the spatial resolution less than one micrometer and the detector detection efficiency of 66% are accessible.
From experimental view, the AAO nanoporous template with average pore diameter of 240 nm and porosity of 30% was fabricated by anodizing the Aluminum. The ZnO was deposited in AAO nanopores by electro-deposition method. By using a new setup, some detection properties of ZnO nanowires electrodeposited in AAO nanoporous template were extracted. The results show that for 12 μm thickness of nano scintillator and the energy of 9.8keV near the K-edge of ZnO (9.65 keV), the detection efficiency of nano scintillator for direct X-rays is 24%. In addition, it is found that all the X-rays that are absorbed in 300 nm thickness of the gold layer (electrical contact for electrodeposition) on the top of zinc oxide nano wires can participate in scintillation process with efficiency of 6%. So, the scintillation detection efficiency of the whole detector for 9.8 keV X-ray energy is 30%. The extracted light yield of zinc oxide nano scintillator is around 5500 photons per MeV energy deposition which is around 60% of the light yield of single crystal ZnO scintillator (9000). Much better spatial resolution of this radiation hard nano scintillator in comparison to bulk ones is an advantage which candidates this nano scintillator for imaging or even for particle tracking in high energy physics applications.
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[3] A. Taheri, S. Saramad, S. Ghalenoi, S. Setayeshi, The European Physical Journal C 73 (2013) 1-7.

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