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High-Res Gamma Ray Multiplier Tubes (HGMTs) Based on Surface Direct Conversion in Laminar MCPs

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We have proposed a method of constructing large-area MCPs by stacking thin, patterned laminae on edge to form laminar MCPs (LMCPs^{TM}) with applications in gamma ray detection for TOF-PET and high-energy physics experiments. The laminae are first patterned with channels of arbitrary shape and size so that when stacked, they form pores as in a traditional MCP. Since the laminae are coated with resistive and secondary-emitting layers before stacking, methods other than ALD, such as CVD, can be used. Pore functionalization is completed before stacking, introducing additional parameters for controlling the shower development. Non-planar and curved slab geometries are also possible.

A package of LMCPs optimized for gamma ray conversion and signal amplification forms the high-resolution gamma ray multiplier tube (HGMT^{TM}). Gamma ray detection is accomplished through surface direct conversion: 511 keV gamma rays interact in the LMCP via the photoelectric and Compton effects to create an electron near a pore surface that escapes the substrate and generates an electron cascade towards an anode. This eliminates the scintillator and photodetector sub-systems in conventional PET scanners, and allows assembling the HGMT at atmospheric pressure in a package with reduced vacuum requirements.

We present simulations of HGMTs and the current progress towards creating an LMCP and measuring its detection efficiency. Geant4 simulations of a $20 \times 20 \times 2.54$ cm^3 LMCP composed of 150-micron thick lead-glass laminae predicts a $\geq 30\%$ conversion efficiency to a primary electron that penetrates an interior wall of a pore. The efficiency rate to produce a low-energy cascade of secondary electrons will be tested by comparing the gamma ray detection rate in the LMCP to a PMT scintillation counter. TOPAS simulations of the Derenzo and XCAT brain phantoms imaged by a whole-body scanner of HGMTs indicate dose reductions of factors of 100 from literature benchmarks.

Collaboration

Role of Submitter

I am the presenter

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