AbstractID: 7778 Title: High Quantum Efficiency Portal Imaging Using a Structured Fiber-Optic Scintillation Glass Array (FOSGA)

ABSTRACT

Purpose: Preliminary studies of a high quantum efficiency (QE) portal imager based on a fiber-optic scintillation glass array (FOSGA) within a focused polymer-tungsten grid and coupled to a-Si photodiodes are presented. These include characterization of intrinsic imaging performance using Monte Carlo simulations and validation of mechanical fabrication accuracy and automated glass fiber insertion.

Method and Materials: The scintillator array comprises of high-density Tb-activated scintillation glass (proprietary material composition) fibers drawn into uniform fiber-optic bundles. The polymer-tungsten grid is constructed using tomo-lithographic molding (TLM), a patent-pending manufacturing technology that can create precisely focused grids using cast-molding and stack-lamination. Glass fibers are inserted using an automated loading jig based on electrostatic alignment and vaccum gradients for precise pixel loading. Monte Carlo simulations were used to model the effects of scintillator geometry (thickness and fill factor) on intrinsic detector performance indicated by the modulation transfer function (MTF), and detective quantum efficiency (DQE).

Results: Results indicated that DQE(0) increased and MTF decreased with scintillator thickness and fill factor. However, upon calculating $DQE(f) \approx DQE(0)MTF(f)^2$, it was found that the effect of thickness and fill factor on DQE(0) was more significant than that on the MTF. Intrinsic QE = 0.43 and DQE(0) = 0.25 could be obtained for a 5 cm thick scintillator array with a fill factor $\geq$ 70%.

Conclusions: FOSGA provides high QE due to good x-ray absorption, scintillation, and fiber-optic coupling characteristics of Tb-glass fibers, while the polymer-tungsten grid improves spatial resolution by limiting the spread of secondary electrons leading to greater MTF and DQE. Based on high QE, high DQE megavoltage imaging in conjunction with cost-effective methodologies for accurate (±3%) mass-production of large-field uniform detector arrays, FOSGA is well suited for 2D localization and verification imaging as well as megavoltage computed tomography (MVCT) for image guided radiation therapy (IGRT).