Thin-film Organic photocell (OPV) properties in MV and kV beams for dosimetry applications

We evaluated a series of thin film organic-based photovoltaic (OPV) cells of various sizes and thicknesses to characterize their response to kV and MV x-ray beams. With proper calibrations the OPV cells their intended application would be as water-equivalent dosimeters for quality assurance and radiation safety purposes. OPV cells are less sensitive to x-ray photons compared to visible light; however the signals generated when the cell are irradiated to x-ray beam turn out to be stable, reproducible and linearly proportional to the absorbed dose. The results below demonstrate that OPV cells have great potential as low cost MV/kV dose imaging material.

The OPV cells comprise of organic thin films sandwiched between two electrode materials (ITO and AL). The thickness of the organic thin films range between 250 – 450 nm with the size of: 0.09, 0.25, 1.00 and 2.00 cm². These OPV cells were evaluated for their responses to kV and MV x-ray beams. The OPV cells were irradiated with 6MV and 10MV beams to evaluate the stability and reproducibility of their response to irradiation for various irradiation duration. The signals were measured in units of ADC and the area under the curves indicates the absorbed dose during irradiation. The dependence of the OPV cells responses to the x-ray energy (6 MV, 10 MV) were also characterized. The practical sensitivity of the cell were characterized using IMRT sweeping gap test generated with gap size ranging from 1 mm to 20 mm. The reproducibility and linearity of the OPV cells responses to kV beam (energy: 60 – 120 kVp) were characterized. In addition, the same tests were performed with and without a thin plastic scintillator to enhance the signal for low dose conditions which may occur in radiation protection applications.

When irradiated with kV and MV beams, the OPV Photocells showed good response with stable and reproducible signals. The cells response was linearly proportional to the size and inversely proportional to the thickness of the organic thin film (Figure 1). There was no clear correlation observed between MV beam dose rate and the size of the organic thin film. The sweeping gap tests performed showed that OPV cells has sufficient practical sensitivity to measured MV x-ray deliver with gap size as small as 1 mm (Figure 2) and therefore could be useful for dosimetry measurement in patient specific IMRT QA.

When irradiated with the kV beams from a fluoroscopy unit, the OPV cell response were linearly proportional to the kV beam energy and the x-ray exposure (Figure 3). The plastic scintillator enhanced the photocell response by a factor of three. The small size (0.09cm²) of the organic thin film used showed promising potential in the development of low cost kV imaging device.

The linearity and reproducibility of the detected signal showed that when calibrated properly, these OPV cells can be used for online radiation dose measurement for QA and radiation protection purposes.