An Optimization of Super-Miniature X-ray Target

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1. Introduction

Electronic brachytherapy is now becoming popular because it has certain advantages over the radionuclide-based brachytherapy sources. Unlike radionuclide-based source, electronic brachytherapy system generates radiation using an X-ray tube [1]. In case of radionuclide-based source, radiation is always produced regardless of needs. But X-ray produced from electronic brachytherapy system can be turned on and off thus we can get only the desired X-ray. Secondly, the dose rate can be easily controlled by adjusting operating voltage and current of electronic brachytherapy system. Lastly, electronic brachytherapy system precludes the hazards of handling the radioactive source [2, 3].

When we use the radiation for brachytherapy or intra-cavity imaging, one of the important concerns is the uniformity of X-ray dose distribution. Dose distribution from electronic brachytherapy system is determined by structure and geometry of X-ray target [4].

2. Methods and Results

In this section MCNP simulation tools of X-ray intensity in X-ray target and simulation results are described. The X-ray target is generally classified reflection and transmission type. X-rays generated from reflection target are generally emitted to backward and side direction and contribution in forward is weak. On the other hand, X-rays produced transmission target are mainly emitted to forward direction and contribution in the backward and side direction is relatively weaker than forward direction.

2.1 Simulation Tools

In this research MCNP is used to calculate X-ray intensity produced from various X-ray targets. We employed MCNP point detector tally. The point is located 1cm away from center of mass of X-ray target. X-ray target material is tungsten and materials of x-ray window used beryllium. An electron beam has 50 keV energy and a size of 3 mm.

2.2 Reflective conical Target

X-ray generated from reflective conical target contributes in the side direction near 100^{o}. On the other hand, X-ray generation is weak in the forward and backward direction. Figure 1 explains the simulation result of reflective conical target.

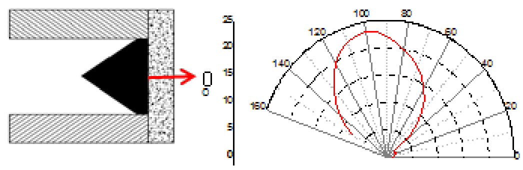

Fig. 1. Reflective conical target

2.3 Truncated conical transmission target

Transmission targets are fabricated by coating x-ray target materials on the X-ray window. Transmission target is classified as planar, spherical, conical and truncated conical type. Compare to simulation results of various transmission target, X-ray intensity of truncated conical transmission target is best uniform spatially. But X-ray intensity of backward direction is still weak. Figure 2 explains the simulation result of truncated conical transmission target.

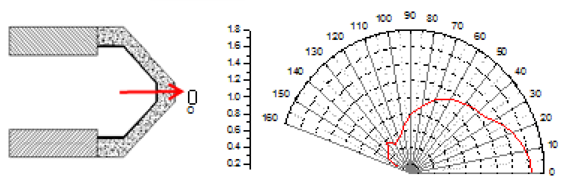

Fig. 2. Truncated conical transmission target

2.4 Optimization of X-ray Target

We can get optimized x-ray target shape (truncated conical transmission type) by various MCNP simulations results. To optimize X-ray target, we don't know specification of truncated conical transmission target such as con-angle and target thickness. By changing the con-angle and target thickness we can get optimized X-ray target. At optimized condition, X-ray target has 90^o of con-angle and 1.5μm of thickness. Figure 3 is the optimized X-ray target in the X-ray tube.

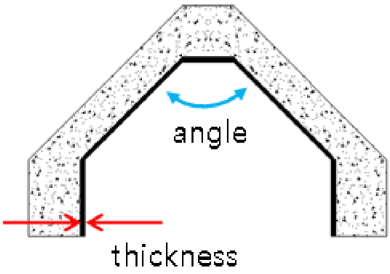

Fig. 3. Optimized X-ray target for electronic brachytherapy system or intra-cavity imaging.

3. Conclusions

MCNP simulation can be useful tools for optimized X-ray target design. To use the optimized target in super-miniature X-ray tube for electronic brachytherapy system or intra-cavity imaging, we face some problems while we fabricate X-ray tube assembly. If these problems are solved well, the electronic brachytherapy system makes patient to be comfortable life.

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