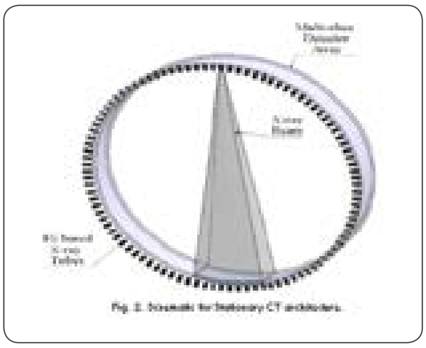
Hyoung K Lee et al., J Mol Imaging Dynam 2018, Volume 8
DOI: 10.4172/2155-9937-C1-002

Compact X-ray tubes for stationary CT architecture

Hyoung K Lee and **Ashish Avachat**
Missouri University of Science and Technology, USA

For imaging arrhythmia patients with cardiac computed tomography (CT), a temporal resolution <50 msec is desired, which cannot be delivered by conventional CT architectures with a rotation gantry. By eliminating the physical rotation of the gantry and electronically sweeping X-ray beams across the gantry, stationary CT architecture can achieve a temporal resolution <50 msec. Stationary CT architecture utilizes a stationary gantry comprising separate arrays for distributed X-ray sources and detectors. These individual X-ray sources are required to be compact, fast, and individually addressable in order to acquire 200+ projections for successful CT reconstruction and achieve a temporal resolution <50 msec. A compact X-ray tube that fits these requirements is being developed. The aim of the present research is to develop and study the first-generation prototype compact X-ray tube primarily consisting of a CNT-based cold cathode and a transmission type anode. Monte Carlo simulations were conducted to compare tungsten, molybdenum, and rhodium as target materials and to optimize the target thickness for a transmission type anode. Using a particle-in-cell technique, the electron focusing was studied to design an electrostatic focusing lens for achieving <1 mm focal spot size (FSS) of X-ray generation in the prototype. The prototype was studied experimentally to understand the performance of the prototype and its control parameters. The results of these simulations and experiments showed the following: CNT-based cold cathode can generate electron pulses with frequencies up to hundreds of kilohertz; an electrostatic lens can achieve the required <1 mm FSS; the lens aperture, thickness, and location can be used as a coarse control on the FSS, while the lens potential can be used as a fine control; and X-ray energy spectra from a transmission type anode is similar in shape to the energy spectra from a conventional reflection type anode after filtration.



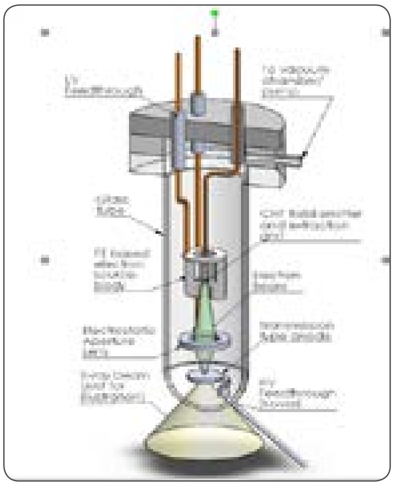


Figure 1: Schematic for a stationary CT architecture.

Figure 2: Schematic for a compact X-ray tube.

Recent Publications

1. Bingham A and Lee H K (2018) The viability of ADVANTG deterministic method for synthetic radiography generation. Comput. Phys. Commun. 228:5-10.
2. Posada C M et al. (2012) Simulation of the electron field emission characteristics of a flat panel X-ray source. J. Vac. Sci. Technol. B. 30(2):2201.
3. Grant E et al. (2012) A Monte Carlo simulation study of a flat-panel X-ray source. Appl. Radiat. Isot. 70(8):1658-16.

Biography

Hyoung K Lee is an Associate Professor and Chair of Nuclear Engineering at Missouri University of Science and Technology (USA). He has his expertise in radiation detection and imaging. He has worked in teaching hospitals as a Medical Physicist and has also been a Faculty Member in academia since receiving his PhD from the University of California at Berkeley. His research area includes radiation detector design and characterization, advanced radiation sources, advanced imaging systems using X-ray, gamma ray or neutron, algorithms for CT reconstruction, image processing, image analysis, and application of deep learning for medical imaging. He has successfully conducted many research projects that covered a wide spectrum of radiation detection and imaging technologies, from development of radiation detectors to development of image enhancement algorithms (some of which were transferred to industry). His current research includes development of flat-panel X-ray sources, compact X-ray tubes for stationary cardiac CT and switchable radioisotopes for imaging and other applications. He has published more than one-hundred forty peer-reviewed publications and edited a book chapter in his field of research. He has also given twenty-five invited lectures and one-hundred and nine abstracted talks.

leehk@mst.edu

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