DPP13-2013-000770

Abstract for an Invited Paper
for the DPP13 Meeting of
the American Physical Society

Novel multi-beam X-ray source for vacuum electronics enabled medical imaging applications[1]

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For almost 100 of years, commercial medical X-ray applications have relied heavily on X-ray tube architectures based on the vacuum electronics design developed by William Coolidge at the beginning of the twentieth century. Typically, the Coolidge design employs one hot tungsten filament as the electron source; the output of the tube is one X-ray beam. This X-ray source architecture is the state of the art in today's commercial medical imaging applications, such as Computed Tomography. Recently, GE Global Research has demonstrated the most dramatic extension of the Coolidge vacuum tube design for Computed Tomography (CT) in almost a century: a multi-beam X-ray source containing thirty two cathodes emitting up to 1000 mA, in a cathode grounded – anode at potential architecture (anode up to 140 kV) [1,2]. This talk will present the challenges of the X-ray multi-beam vacuum source design – space charge electron gun design, beam focusing to compression ratios needed in CT medical imaging applications (image resolution is critically dependent on how well the electron beam is focused in vacuum X-ray tubes), electron emitter choice to fit the aggressive beam current requirements, novel electronics for beam control and focusing, high voltage and vacuum solutions, as well as vacuum chamber design to sustain the considerable G forces typically encountered on a CT gantry (an X-ray vacuum tube typically rotates on the CT gantry at less than 0.5 s per revolution). Consideration will be given to various electron emitter technologies available for this application – tungsten emitters, dispenser cathodes and carbon nano tubes (CNT) [3, 4] – and their tradeoffs. The medical benefits potentially enabled by this unique vacuum multi-beam X-ray source are: X-ray dose reduction, reduction of image artifacts and improved image resolution.

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[2] "High power distributed X-ray source," K. Frutschy, B. Neculaes, L. Inzinna, A. Caiafa, J. Reynolds, Y. Zou, X. Zhang, S. Gunturi, Y. Cao, B. Waters, D. Wagner, B. De Man, D. McDevitt, R. Roffers, B. Lounsberry, N. Pelc, Proceedings of SPIE, vol. 7622 76221H-1, 2010
[3] "Analytical study of electron gun temporal current response as a function of electron emission mechanism," V. B. Neculaes, A. Caiafa and Y. Zou, 21st International Vacuum Nanoelectronics Conference Technical Digest, p. 94, ISBN : 83-914886-2-4, 2008
[4] "Role of plasma activation in kinetics of carbon nanotube growth in plasma-enhanced chemical vapor deposition," I.V. Lebedeva, A. A. Knizhnik, A.V. Gavrikov, A. E. Baranov, B. V. Potapkin, D. J. Smith, and T.J. Sommerer. Journal of App. Phys., 111, 074307, 2012

[1]This work was funded in part by NIH grant R01EB006837.