Innovative Carbon Nanotube-based Field Emission Electronics for X-ray Generation & Imaging

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Abstract:

The X-ray, a foundational technology since its discovery in 1895, continues to be widely utilized across many areas and aspects of scientific research, development, and industry. However, the conventional X-ray sources remain rooted in thermionic electron emission, which involves heating a tungsten filament to around 2000°C to release electrons into a vacuum. Despite its simplicity, this approach presents limitations, including slow temporal response, substantial physical size, and high energy consumption. To address these challenges, we study a comprehensive project centered on the development of carbon nanotubes (CNTs)-based field emission electronics on silicon chip emitting digitally controlled electron beams for revolutionary X-ray generation & imaging. Our objectives encompass reducing temporal response from hundreds of milliseconds to less than 100 microseconds, minimizing physical dimensions, shrinking focal spot sizes from a few of square millimeters to micro-nano scale, lowering power consumption, and enabling fast-switching pulsed sources. Our approach will hinge on an in-depth understanding of CNTs-based field emission mechanisms, incorporating nanomaterial and device modeling, innovating vertically self-aligned and gated CNTs on silicon chip, device structure design and fabrication, as well as system design & integration. This work will seek to usher in a disruptive and innovative era of X-ray generation & imaging technologies with the potential to transform industries, enhance homeland security, and improve people's lives. By leveraging cutting-edge electronics & nanotechnology, we aim to reshape the landscape of X-ray applications and open doors to new possibilities.