

## Carbon Nanotube X-Ray: Promises and Challenges

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**Purpose:** To develop a carbon nanotube based field emission x-ray technology for medical imaging and radiation therapy

**Method and Materials:** Carbon nanotubes (CNTs) are used as the field emission “cold cathode”. The x-ray tube current is generated by applying an external electrical field to extract the electrons from the CNTs. By varying the extraction electrical field, x-ray radiation with programmable waveforms can be readily generated and gated with physiological signals. Spatially distributed x-ray source arrays with one- and two-dimensionally distributed focal spots are constructed by using matrix addressable multi-pixel CNT cathode. Switching, scanning, and regulating the x-ray beams are achieved by specially designed gate control electronics.

**Results:** Programmable and spatially distributed field emission x-ray source arrays have been developed. After substantial R&D efforts these x-ray sources are now capable of delivering the spatial resolution, the x-ray flux, and the energy required for medical imaging applications. Utilizing the rapid programmable capability of the CNT field emission source, a prospective respiratory and cardiac gated micro-CT scanner has been developed that is capable of high-resolution in vivo imaging of free-breathing small animals. A proof-of-concept stationary digital breast tomosynthesis scanner with a distributed multi-beam x-ray source array has been demonstrated which collects project images without mechanical motion and has the potential to substantially reduce the scanning time and therefore motion blurs. Utilizing the capability of distributing the x-ray power over a large focusing track instead of small spot on the anode, a compact high dose and dose rate microbeam radiation therapy system is currently under development at UNC.

**Conclusion:** The distributed field emission x-ray source array technology offers unique capabilities that are attractive for tomography imaging and potentially for radiotherapy. The flexibility in source configuration opens up new possibilities in system design. As a brand new source technology, issues such as reliable and long term stability which are critical for commercial products need further investigation and improvement.

**Conflict of Interest (only if applicable):**

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Zhou is a board director of XinRay Systems which develops and commercializes the CNT X-Ray source technology.