Vertically aligned multi-walled carbon nanotube (MWCNT) arrays for X-ray sources applications

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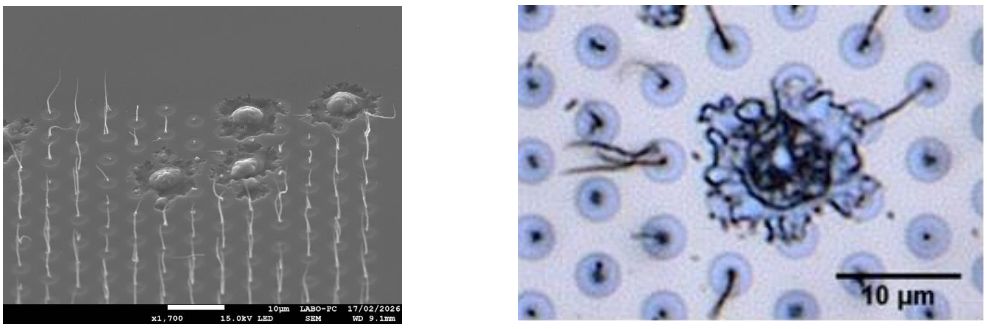
ABSTRACT

Carbon nanotubes (CNT) have generated significant interest as field emitters in electron emission applications [1], primarily due to their high aspect ratio and nanometer-scale apex radius. These characteristics enable local field amplification, allowing CNT to achieve electron emission at relatively low applied voltages and to respond almost instantaneously to variations in the electric field. As such, CNT are promising candidates for next-generation X-ray sources [2]. We develop vertically aligned CNT arrays as cold cathodes for X-ray tubes, targeting applications that require operation with pulse widths on the order of hundreds of microseconds.

Plasma-enhanced chemical vapor deposition (PECVD) enables precise control over the growth, morphology, and electrical emission properties of CNT arrays. Using this technique, we have developed CNT arrays with surface areas of a few square millimeters, achieving emission current densities of up to 1 A/cm². We investigate electron emission under dynamic vacuum conditions, CNT cathodes. Both morphological and electrical evolutions are systematically monitored. Aging experiments were conducted over 1.5×10^9 pulses at a current density of 0,3 A/cm². Ageing phenomena are characterized by analyzing CNT degradation, crater formation, and the evolution of the geometrical field enhancement factor (β). The study is further extended by evaluating the electron emission characteristics using a grid as the extraction electrode in both diode and triode configurations.

By correlating the morphological and electrical evolution of CNT arrays with electrode configuration and operational parameters, this study deepens the understanding of their durability and demonstrates the robustness of CNT emitters and confirm their suitability for long-term operation in X-ray sources



(a) *(b)*

Figure* 1. C*rater formation after ageing

References

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[2] Parmee, R.J., Collins, C.M., Milne, W.I. et al. X-ray generation using carbon nanotubes. Nano Convergence 2, 1 (2015).