276
Accession number:20122915252525
Title:Demonstration of an acid-spun single-walled nanotube fiber cathode
Authors:Shiffler, Don (1); Fairchild, Steve (2); Tang, Wilkin (1); Maruyama, Benji (2); Golby, Ken (3); LaCour, Matthew (3); Pasquali, Matteo (4); Lockwood, Nathaniel (1)
Author affiliation:(1) Air Force Research Laboratory, Directed Energy Directorate, Kirtland AFB, NM 87117, United States; (2) Air Force Research Laboratory, Materials and Manufacturing Directorate, Wright-Patterson AFB, OH 45433, United States; (3) SAIC, Inc., Albuquerque, NM 87117, United States; (4) Rice University, Houston, TX 77251, United States
Corresponding author:Shiffler, D.(don.shiffler@kirtland.af.mil)
Source title:IEEE Transactions on Plasma Science
Abbreviated source title:IEEE Trans Plasma Sci
Volume:40
Issue:7 PART 2
Issue date:2012
Publication year:2012
Pages:1871-1877
Article number:A6
Language:English
ISSN:00933813
CODEN:ITPSBD
Document type:Journal article (JA)
Publisher:Institute of Electrical and Electronics Engineers Inc., 445 Hoes Lane / P.O. Box 1331, Piscataway, NJ 08855-1331, United States
Abstract:Field emission dc cold cathodes continue as an important area of research for uses such as electron microscopy, novel X-ray sources, vacuum electronic devices, terahertz sources, and high-power microwave tubes. Each of these applications typically requires high current densities with high-brightness electron beams driven by cathodes exhibiting long lifetime in the presence of deleterious conditions such as ion back bombardment and excessive heating. The Air Force Research Laboratory (AFRL) now investigates cathodes operating in dc mode for use in a terahertz traveling wave tube (TWT). The TWT requires an electron beam of 50 μm in diameter or less, at 10s of kiloelectronvolt energy with energy spreads of less than 10 eV. While AFRL has tested numerous cathodes in this regime, this paper reports on the first demonstration of a dc cathode utilizing a highly aligned carbon nanotube (CNT) rope for the electron emitter. The rope consists of individual single-walled CNTs that have been subjected to a nitrogen-enhanced acid etch and then spun into a rope configuration. Thus, the single rope emitter has an overall diameter of 100 μm and a length of 1.5 mm. We report on preliminary results from this cathode, in particular the fabrication of the cathode, the dc cathode test system, and the cathode operation up to a voltage of 5 kV. The cathode operates stably to within 0.6% with a 5-mm anode-cathode gap at 5 keV and 1.0-mA current for hundreds of hours. Finally, we provide estimates of the cathode parameters such as the effective field enhancement factor (β<inf>eff</inf> ) and emitting area (A) through a Fowler-Nordheim plot and comparison of the experimental data with simulations utilizing the particle-in-cell code Improved Concurrent Electromagnetic Particle-in-Cell. © 2012 IEEE.

Number of references:72
Main heading:Field emission cathodes
Controlled terms:Cathodes - Electrodes - Electron beams - Electron devices - Electron microscopy - Ion bombardment - Microwave devices - Microwave tubes - Microwaves - Rope - Spinning (fibers) - Traveling wave tubes
Uncontrolled terms:Acid etch - Air Force Research Laboratory - Aligned carbon nanotubes - Anode cathodes - Back bombardment - Cathode operations - Cold cathodes - DC mode - Effective field - Electron emitters - Emitting areas - Energy spreads - Excessive heating - Experimental data - Field emitter arrays - Fowler-Nordheim plots - High brightness - High current densities - High power microwaves - Kiloelectronvolt - Long lifetime - Particle in cell codes - Particle-in-cell - Single-walled - Single-walled nanotube - Tera Hertz - Terahertz sources - Test systems - Vacuum electronic devices - X-ray sources
Classification code:932.1 High Energy Physics - 932 High Energy Physics; Nuclear Physics; Plasma Physics - 819.3 Fiber Chemistry and Processing - 933 Solid State Physics - 715 Electronic Equipment, General Purpose and Industrial - 711 Electromagnetic Waves - 535 Rolling, Forging and Forming - 714.1 Electron Tubes
DOI:10.1109/TPS.2012.2195328
Database:Compendex
Compilation and indexing terms, Copyright 2012 Elsevier Inc.