Santa Clara University

Electron Devices Laboratory (EDL)
Department of Electrical Engineering
&
NASA Ames Research Center

Present
Ph.D. Dissertation Defense

Monday, June 1, 2009, 3-5 PM
Bannan Engineering Building, Room 230

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Development and Characterization of a MEMS Based Carbon Nanotube Field Emission Electron Source Technology for High Resolution Applications

Abstract: Due to their chemical structure, carbon nanotubes (CNTs) possess unique physical, mechanical, and electrical properties which are valuable for advanced electron beam applications. In particular, the high aspect ratio and small tip radius of the individual carbon nanotube make it an excellent field emission electron source for high resolution applications. At the NASA Ames Research Center, the Microcolumn Scanning Electron Microscope and EDX Spectrometer (MSEMS) is being developed. The MSEMS, a spaceflight instrument, will be capable of high resolution spatial imaging and elemental analysis of planetary and interplanetary rocks and minerals which leave clues to their history in the form of chemical and physical changes. The MSEMS will be a miniaturized version of the laboratory scanning electron microscope (SEM) with an optical column length of less than 1 cm. Field deployment of the MSEMS for in situ sample analysis from a spacecraft such as the Mars Exploration Rover is possible because of its small size. The enabling technology for device miniaturization is an individual carbon nanotube electron source. With the CNT field emitter's characteristically low energy spread and high brightness, a microcolumn SEM can achieve a small probe diameter with a short optical column.

The objective of this work, through collaboration between the Electron Devices Laboratory (EDL) and NASA, is to develop and characterize the carbon nanotube electron source technology for the microcolumn SEM. A novel microelectromechanical systems (MEMS) based technique for fabrication of a single CNT field emission cathode will be presented. This technique produces CNT cathodes which are electrically and mechanically more reliable than previous fabrication methods. Also, design rules for the overall cathode geometry for optimization of the CNT's field emission characteristics will be introduced. Furthermore, a circuit model to represent the CNT electron source will be revealed which will be valuable for design of system electronics. Lastly, experimental results of a MEMS based CNT field emission electron source will be presented. The results of this research offer a solution for integration of an individual carbon nanotube field emission electron source into a microcolumn SEM.

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Refreshments will be served