Characterization of a Carbon Nanotube Field Emission Electron Gun for the VAPoR Miniaturized Pyrolysis-Time-of-Flight Mass Spectrometer

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Low power, robust technologies are appealing for in situ planetary science throughout the Solar System. We are developing the VAPoR (Volatile Analysis by Pyrolysis of Regolith) instrument towards studying soil composition, volatiles, and trapped noble gases in the polar regions of the Moon. VAPoR will ingest a soil sample and conduct analysis by pyrolysis and time-of-flight mass spectrometry (TOF-MS). We will describe miniaturization efforts within this development, including a carbon nanotube (CNT) field emission electron gun that is under consideration for use as the electron impact ionization source for the ToF-MS. The cathode consists of a patterned array of CNT towers grown by catalyst-assisted thermal chemical vapor deposition. Ultra-clean MEMS fabrication and integration techniques were employed toward three goals: low extraction voltage (<100 eV) during operation to be resonant with gas ionization energies, maximized current transmission through the grid, and mitigation of current fluctuations due to adsorbate-assisted tunneling. We have characterized the performance of the CNT cathode and integrated electron gun through rigorous modeling, current-voltage measurements, and emission lifetesting at variable partial pressures of nitrogen gas to investigate the effects of mechanical sputtering. Implications for *in situ* mass spectrometry in planetary science will be discussed.