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ABSTRACT
We are developing the VAPoR (Vapor Phase Analysis by Pyrolysis and Reaction) 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). Here, we describe miniaturization efforts within the 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.

APPLICATION
The miniaturized time-of-flight mass spectrometer development will enable analysis of evolved gas from regolith and planetary atmospheres. Our plan is to use CNT-emitting electron emitters for their high electron concentration, high self-bias, and manufacturability to develop a patterned cathode for the electron impact ionization component of the VAPoR instrument.

METHODOLOGY
We modeled and built a CNT field emission electron gun using patterned catalyst-assisted chemical vapor deposition for the CNT cathode and silicon micromachining for the extraction grid and electrostatic lens elements.

INTRODUCTION
A miniaturized ToF-MS is under development at NASA GSFC to enable in situ chemical analysis of lunar regolith using a low-power, low-mass, small-footprint package. An aliquot of regolith will be ingested into one of six sample cups. Thermal pyrolysis will release volatiles that can be analyzed by the electron impact ToF-MS.

RESULTS
In a high vacuum test chamber, we cooled current at the grid and at the anode as a function of extraction voltage to evaluate performance of the cathode. A fit to Fowler-Nordheim tunneling shows a field enhancement factor of 900, consistent with previous reports in the literature. The power consumption for this e-gun is only 1 mW, compared to >100 mW for thermionic technology.

CONCLUSIONS
A CNT field emission electron gun has been designed, fabricated, tested, and integrated with the VAPoR ToF-MS prototype. Several iterations of current are produced using conservative operating parameters, and lifetime up to several hundred hours can be achieved in high vacuum. An unoptimized mass spectrum has been obtained using the integrated ToF-MS prototype.

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SELECTED REFERENCES