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Absolute Electron Emission Calibration: Round Robin Tests of Au and Polyimide

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Absolute Electron Emission Calibration: Round Robin Tests of Au and Graphite

Introduction

Accurate determination of the absolute electron yields of conducting and insulating materials is essential for models of spacecraft charging and related processes involving charge accumulation and emission due to electron beam and plasma interactions. Measurements of absolute properties require careful attention to calibration, experimental methods, and uncertainties.

This study presents a round robin comparison of these absolute yields performed in four international laboratories. The primary objectives were to determine the consistency and uncertainties of such tests, and to investigate the effects of the similarities and differences of the diverse facilities. Apparatus using various low-fluence pulsed electron beam sources and methods to minimize charge accumulation have been developed and employed at these facilities.

Measurements were made for identical samples with reproducible sample preparation of three standard materials:

- the elemental conductor Au (50 µm thick Au film)
- the elemental semiconducting HOPG (30 cm high purity graphite)
- the polymeric insulator polyimide (25 µm thick Kapton® film)

Total electron yields (TEY) of Au and HOPG are reported here. Absolute electron yield measurements for various materials are necessary to determine absolute charge levels and hence to predict possible electronic breakdown and injection of charges into plasmas. They have direct application to spacecraft charging, high voltage direct current (HVDC) power and transmission lines, ion thrusters, plasma deposition, multipactor, semiconductor metal oxide interfaces, and nanoelectronics.

References


Descriptions of Facilities and Methods

CSIC SEY Facility

The CSIC SEY Facility of the Surface Engineering and Nanotechnology Facility at CSIC (SEY) is a white light tunable soft-x ray source at temperatures of 300-1500 K. We have studied how x-ray sources, temperature, and sample surface radiation effects differ from these properties in solid samples and have related changes in structure, chemical and optical properties to electrons and systems.

Onera DEES Facility

The DEES Facility (Département d’Etude des Emissions Spontanées) at Onera is a UV-visible nanosecond laser-pulsed electron source. The Space Environment Department uses it in many projects closely related to space applications, including plasma discrimination, electron mechanisms, and Wall Effect Technology (WET).

LaSEINE TEEY Facility

The Laboratory of Spacecraft Engineering (LaSEINE) at Kyushu Institute of Technology (Kanazawa) has studied spacecraft charging and discharging. We have determined the Total Electron Emission Yield (TEEY) measurement facility to evaluate the accuracy and reliability of the charging analysis tool MAGIC. We have measured the electron yield of several spacecraft materials using the measured TEEY after completion with guiding radiators, antenna covers, and other components.

Measurements capabilities include:

- Vacuum analysis chamber below 10^-9 Pa
- Electron dose: 300-10°C keV
- Sample Stage temperature: ± 180°C
- Sample holder temperature: ± 75 K

Total electron emission yield measurement method:

Sample holder and collector are biased at -3000 V and 1000 V, respectively. The example of electron emission of the sample surface is shown here with using standard electron beam.

USU SEEM Facility

The Utah State University Physics Materials Group (USU) Space Environment Effects Facility (SEEF) performs electron-surface interaction studies and electron transport properties of both conducting and insulating materials, emphasizing study of electron emission, conductance, and ion fluence effects on spacecraft surfaces.

Measurements include:

- Total surface analysis: Electron Emission using -0.5 to 6 keV test-nontoxic energies and pulse bias with high signal elimination.
- Electron Emission Spectra: energies 0.5-6 keV with -0.5 keV resolution
- Surface Voltage: electron emission spectra and yields for volatiles (Kapton, Polyimide, etc.)
- Surface Emission Spectra: electron emission spectra and yields at 0.45 keV for (100) 2000 micron-machinability polyimide.
- Surface Emission Spectra: electron emission spectra and yields at 0.45 keV for (100) 2000 micron-machinability polyimide.

Round Robin Tests Results

Measurements were made of the absolute electron yields at normal incidence over the full range of incident energies accessible with each group’s instrumentation (a full range of ±5 eV to ±5 keV). Figures show linear plots with low energy detail ins (left) and log-log plots of scaled yields (right) versus scaled energy (E/keV)