Measurement of Secondary Electron Yield from Dielectric Materials

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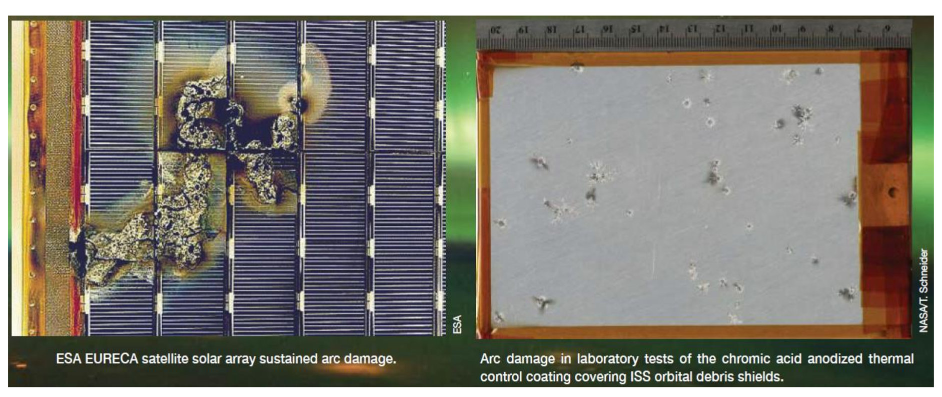
MOTIVATION

Secondary Electron Yield (SEY) is a material property that plays a fundamental role in material and spacecraft charging. SEY values for dielectric materials (insulators) are crucial inputs to models used to assess mission risk posed by high differential voltages and electrostatic discharge (ESD) on spacecraft. There are only two (non-NASA) facilities that attempt such measurements. The lack of NASA capability results in high cost and long, unpredictable schedules to obtain measurements. Future Artemis crewed lunar surface missions will involve the first use of many insulating materials for which SEY properties are poorly understood or absent entirely. Unconstrained SEY values in models increase uncertainty in charging/ESD risk assessment. The capability for reliable SEY determination will lead to improved charging and ESD risk assessments. We are developing a new capability, using pulsed ultralow (<femtoampere) incident electron beam intensity to eliminate sample charging, coupled with sensitive non-contact surface potential measurements, to measure secondary electron yield (SEY) from insulating materials. Present methods for SEY measurement on insulators suffer from highly inconsistent results due to sample charging from the incident electron beam during the measurement. In this first phase we are leveraging existing EM41 instrumentation, facilities, and expertise to perform proof-of-concept tests.



Source: NESC 2016 Tech Update

Spacecraft	Year(s)	Orbit	Impact*	Spacecraft	Year(s)	Orbit	Impact*
DSCS II	1973	GEO	LOM	Intelsat K	1994	GEO	Anom
Voyager 1	1979	Jupiter	Anom	DMSP F13	1995	LEO	Anom
SCATHA	1982	GEO	Anom	Telstar 401	1994, 1997	GEO	Anom/LOM
GOES 4	1982	GEO	LOM	TSS-1R	1996	LEO	Failure
AUSSAT-A1, -A2, -A3	1986-1990	GEO	Anom	TDRS F-1	1986-1988	GEO	Anom
FLTSATCOM 6071	1987	GEO	Anom	TDRS F-3,F-4	1998-1989	GEO	Anom
GOES 7	1987-1989	GEO	Anom/SF	INSAT 2	1997	GEO	Anom/LOM
Feng Yun 1A	1988	LEO	Anom/LOM	Tempo-2	1997	GEO	LOM
MOP-1, -2	1989-1994	GEO	Anom	PAS-6	1997	GEO	LOM
GMS-4	1991	GEO	Anom	Feng Yun 1C	1999	LEO	Anom
BS-3A	1990	GEO	Anom	Landsat 7	1999-2003	LEO	Anom
MARECS A	1991	GEO	LOM	ADEOS-II	2003	LEO	LOM
Anik E1	1991	GEO	Anom/LOM	TC-1,2	2004	~2xGTO, GTO	Anom
Anik E2	1991	GEO	Anom	Galaxy 15	2010	GEO	Anom
Intelsat 511	1995	GEO	Anom	Echostar 129	2011	GEO	Anom
SAMPEX	1992-2001	LEO	Anom	Suomi NPP	2011-2014	LEO	Anom

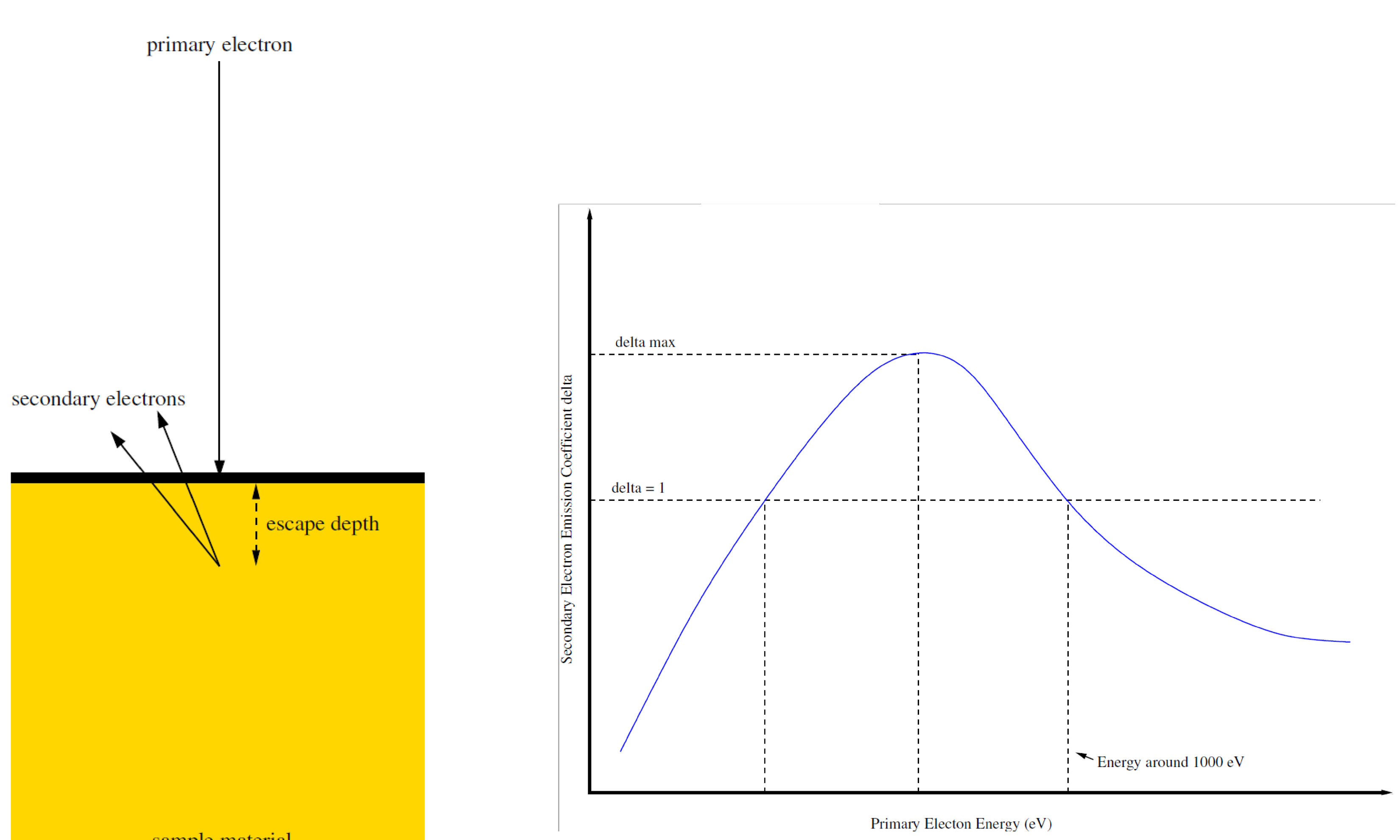
*Anom=anomaly, SF=system failure, LOM=Loss of mission

Mission Anomalies Attributed to Charging

Diagnosis	Number of Incidents
ESD Internal Charging	74
ESD Surface Charging	59
ESD Uncatagorized	28
Single Event Effects	85
Damage	16
Micrometeoroid / Impact Damage	10
Miscellaneous	26

Distribution of incidents by diagnosis (Aerospace report TR-2000(8570)-2; 28 Feb 2001.)

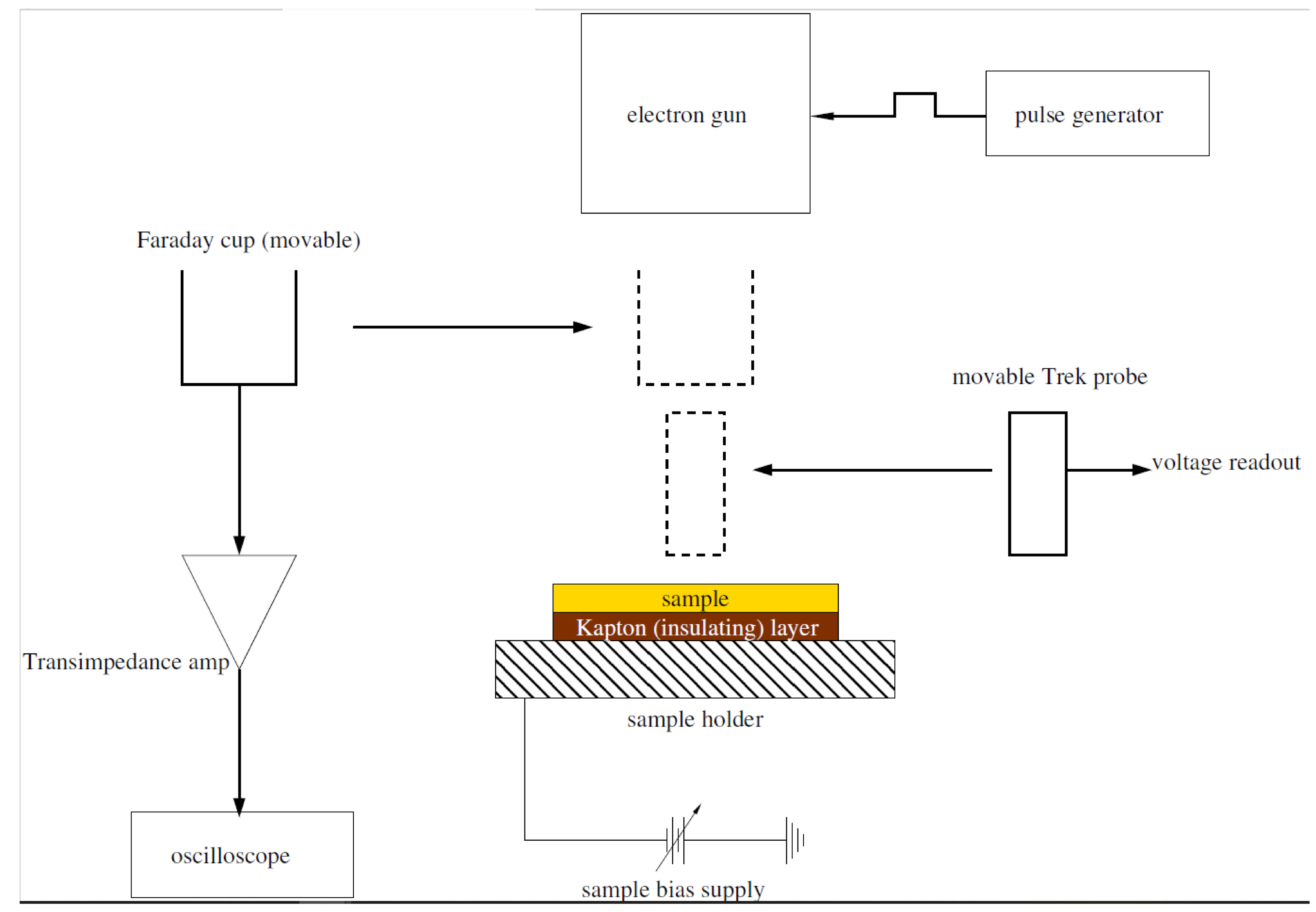
SECONDARY ELECTRON EMISSION



Caption: Left: Sample/beam geometry. Right: Primary electron energy dependence of secondary electron emission coefficient.

Secondary electron emission coefficient ≡ delta = secondary electron current / primary electron current

MEASUREMENT TECHNIQUE



Caption: Test setup schematic. Trek probe = Non-contacting voltage probe

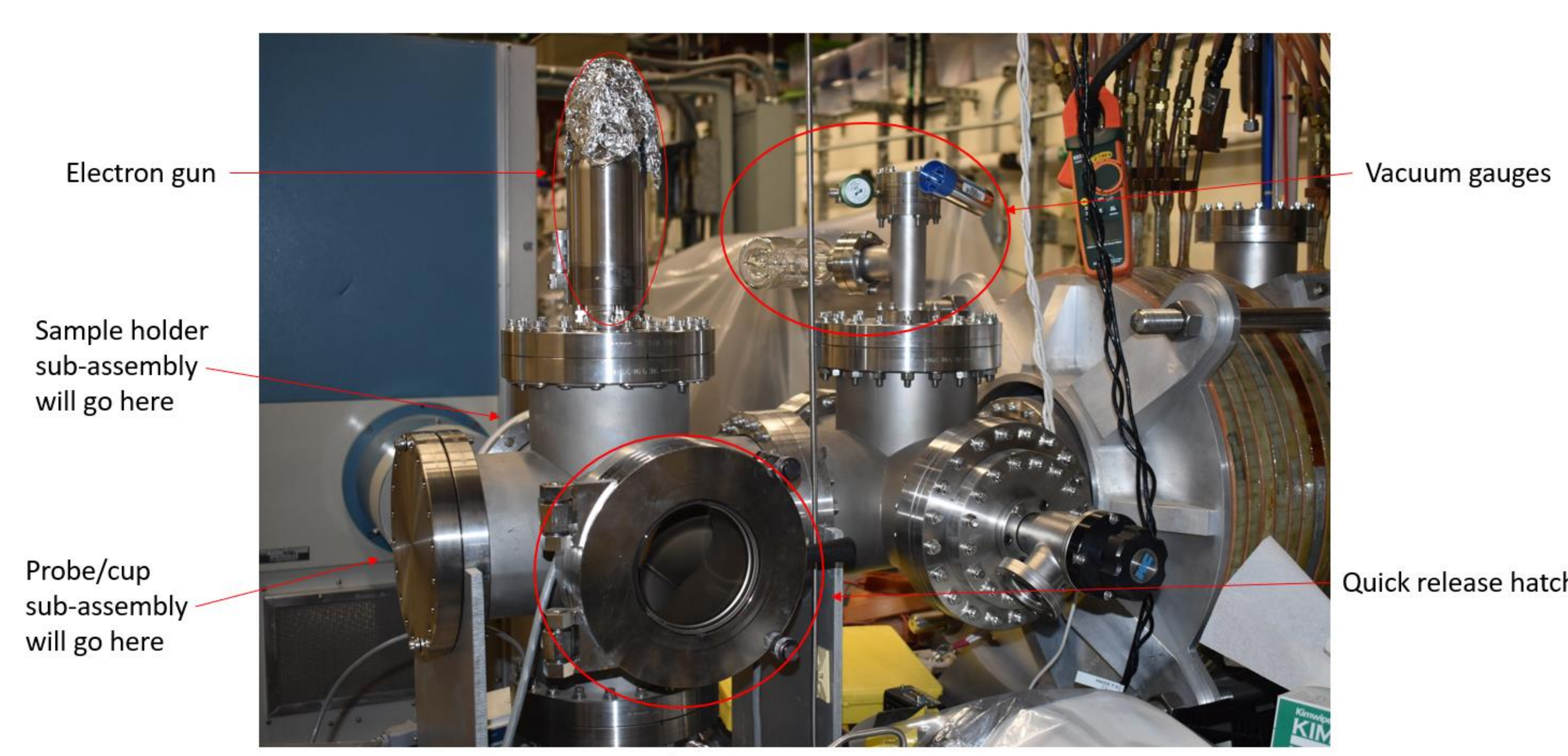
$$\text{delta} = 1 - C\Delta V_s / Qi$$

C = Sample capacitance

Q_i = Charge of incident electron pulse

ΔV_i = Change in surface voltage due to incident electron pulse

PROGRESS TOWARD FIRST PROTOTYPE



REFERENCES

1) M. Belhaj, et al, Nuclear Instruments and Methods in Physics Research B 270 (2012) 120