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PROPOSITION DE SUJET DE THESE

Intitulé : New methods to characterize electron emission of dielectric materials under e- irradiation

Référence : **PHY-DPHY-2024-10** *(à rappeler dans toute correspondance)*

Début de la thèse : Octobre 2024	**Date limite de candidature :** 01/03/2024

Mots clés

Electron impact, Secondary electron, Ultra-HIGH Vacuum, Dielectric, Electric charging under electron irradiation

Profil et compétences recherchées

Master degree in physics : The thesis topic requires a genuine inclination for experimental work

Electron emission under electron impact is a phenomenon that plays a major role in various applications, both in space and non-space domains, such as high-energy physics, electron microscopy, nuclear fusion, particles accelerators, etc. Regarding space applications, electron emission leads to multipactor discharges in RF components [1], electrostatic discharges on the external materials of satellites [2], and affects the plasma thrusters' function [3].

For all these applications, it is important, from both fundamental and applied viewpoints, to characterize the electron emission yield of the materials. While characterization techniques are well-established for electrically conductive materials (metals and semiconductors), such consistency remains to be validated for dielectrics characterization. The charging effects, inherent of electron irradiation during the measurement process, dynamically alter the material's response [4].

The use of dielectrics in RF components of satellites is in constant increase, especially to reduce mass and dimensions. Dielectrics have always been used as coatings for satellites' outer surfaces. Despite the growing and urgent need for electron emission data on dielectric materials, characterization methods and techniques as well as the quality of the produced data remain limited (low precision).

The objective of this thesis is to develop new measurement techniques for electron emission yields specifically tailored to dielectric materials. The student will have the following resources to rely on:

- Robust and validated characterization facilities already available at ONERA [5].
- Internationally recognized expertise in the field of electron emission with plenty of previous related work (PhD, postdocs, R&D studies, …).
- Simulation tools for electron-material interaction [6] and experimental setup mockup.

In order to develop his/her own experimental setup during the thesis, all the necessary instruments are available as well as a vacuum chamber dedicated to PhD works.

The thesis topic requires a genuine inclination for experimental work and initiative while the doctoral candidate will get support from experimental experts from ONERA and CNES. It is essential that he/she demonstrates a certain degree of independence in conducting his/her PhD work.

[1] J. R. M. Vaughan, "Multipactor," in IEEE Transactions on Electron Devices, vol. 35, no. 7, pp. 1172-1180, July 1988

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[3] Antoine Tavant, Vivien Croes, Romain Lucken, Trevor Lafleur, Anne Bourdon, et al.. The effects of secondary electronemission on plasma sheath characteristics and electron transport in an ExB discharge via kinetic simulations. Plasma

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[4] Q. Gibaru, C. Inguimbert, M. Belhaj, M. Raine, D. Lambert,

Monte-Carlo simulation and experimental study of the effect of internal charging on the electron emission yield of amorphous

SiO2 thin films, Journal of Electron Spectroscopy and Related Phenomena, Volume 261, 2022, 147265,

[5] Paulmier, B. Dirassen, M. Belhaj, V. Inguimbert, S. Duzellier, et al.. Experimental test facilities for representativecharacterization of space used materials. 14th Spacecraft Charging Technology Conference (SCTC 2016), Apr 2016,

NOORDWIJK, Netherlands. https://hal.science/hal-01371858/document

[6] Q. Gibaru, C. Inguimbert, P. Caron, M. Raine, D. Lambert, J. Puech,

Geant4 physics processes for microdosimetry and secondary electron emission simulation: Extension of MicroElec to very low energies and 11 materials (C, Al, Si, Ti, Ni, Cu, Ge, Ag, W, Kapton and SiO2), Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, Volume 487, 2021, Pages 66-77

Collaborations envisagées : CNES

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