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Dynamic secondary electron emission in dielectric/conductor mixed coatings

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An unexpected behavior of the Secondary Emission Yield (SEY) on coatings composed by a mixture of conductor and dielectric microparticles was reported and modeled in [1]. As a follow up, we measured for a fixed primary energy the dynamic evolution of the SEY in similar samples and proposed a charging-roughness coupled model to simulate the experimental results. Two different coatings were selected: 1) TMM and Al microparticles (type 1), and 2) zeolites and gold nanoparticles (type 2). Pulsed and continuous tests were used to obtain the SEY as a function of the primary energy.

In both types of samples extremely large first cross-over energy, E^*_1, values (around 1000 eV) and very low-SEY at energies lower than E^*_1 (~0.2) was observed when a 'normal' electron dose (nC) was used, continuous method. This was maintained for the type 1 coatings when a ‘low’ dose (fC, single pulse method with a pulse duration of 180 ns) was used. However, type 2 coatings exhibited usual E_1 values (<100eV) and shape of the SEY curve, when measured by the single pulse method.

When type 2 samples were irradiated at a fixed primary energy (E) by 100 μs-wide pulses with a frequency of 100Hz the SEY transient was registered. For primary energies < E^*_1, the SEY values decreased from the one measured by the single pulse method to the SEY measured with the normal dose (continuous method). Conversely, it was observed for energies larger than E^*_1 that the SEY increased as the charge built up from the values rendered by the single pulse method to the continuous method's values. In all instances the behavior of the SEY did not approach to 1 as the charge built up, as it should do in a usual isolating material. In addition, ~100 s after the electron irradiation was stopped, the sample had recovered its initial SEY, pointing to a charging explanation of this phenomenon.

To simulate this SEY behavior, a model based in both charging and surface roughness is proposed. In this work, conductive and dielectrics materials with different SEY parameters are considered. This mixture of conductor and dielectric materials leads to charge being accumulated at different rates in the different particles or regions of the coating. Together with roughness, these different charging rates, lead to the appearance of electric potentials over the surface that need to be climbed by the secondary electrons in order to be emitted.

Two bi-dimensional profiles of the sample roughness are studied, square and triangular models. For the squared profile the different materials were placed at the top and bottom of the wells and, for the triangular profile, they were placed at the left slope and right slope of each triangular hill. Different values for the initial SEYs of the materials were used and it was found that for specific pairs of values the total SEY of the sample can be strongly diminished and for others it can be enhanced, in accordance with the experimental results.

[1] EXTREMELY LOW SECONDARY ELECTRON EMISSION FROM METAL/DIELECTRIC PARTICULATE COATINGS. I. Montero, L. Aguilera, L. Olano, M. E. Dávila, V. Nistor, L. Galán,J.R. Dennison, G. Wilson.