Electron Emission Effects in Bounded and Dusty Plasma

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Photon, electron and ion bombardment of materials leads to the emission of electrons from the materials. This so-called secondary electron emission (SEE phenomenon is a common link between particle-surface interactions in plasmas, particle accelerators, light sources, and space environments. The plasma-surface interaction in the presence of a strong electron emission is omnipresent in numerous plasma applications such as, for example, cathodes, emissive probes, divertor plasma, surface discharges, dusty plasma, plasma thrusters and plasma processing. In a plasma system, electron and ion fluxes to the wall are determined by particles velocity distribution functions and by the sheath potential, which are consistent with the wall properties. Electrons with sufficient energy to overcome the wall sheath potential and ions accelerated by the sheath potential can impact the wall and produce secondary electrons. The secondary electron emission can then reduce the sheath potential, leading to an increased loss of plasma electrons to the wall, increased wall heating, and increased cooling of the bulk plasma.

Although the role of the secondary electron emission in the above processes and applications has been acknowledged, its effects are neither well characterized nor well understood and therefore, cannot be reliably predicted. For example, electron emission significantly changes the space-charge distribution around emissive probes, adding uncertainty to plasma potential measurements. This status quo is in a great part due to a complex synergistic nature of particle-surface interactions, which often involves a coupling between impinging particles and materials properties and surface geometry. This coupling is particularly strong for plasma-surface interactions. In this problem, plasma and materials sciences are not separable – the plasma and surface interact and evolve together. The plasma science challenges are i) to develop an understanding of SEE effects on plasma and plasma effects on SEE, including but not limited to heating and energy relaxation of emitted electrons in the plasma through collisions and collective effects, surface recombination, surface charging, and surface breakdown, ii) to characterize SEE properties and SEE effects directly in plasma rather than in vacuum as it is commonly done, and iii) to develop control of SEE effects. The materials and surfaces sciences challenges are to understand i) how surface evolves from interaction with plasma, ii) how these surface and materials modifications affect the SEE from these materials, and iii) how to control SEE properties of materials. For example, changing surface properties with various coatings or due to wall erosion, trapping of emitted particles in complex surfaces, nanoscale effects all can significantly alter the electron emission properties of plasma facing surfaces.