Numerical Simulation of Sheath Structure and Current–Voltage Characteristics of a Conductor–Dielectric Disk in a Plasma

(J. Enoch, chairman of dissertation committee)

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This dissertation presents a computer simulation which describes the interaction of a plasma with a conducting disk which is partially covered by an insulator and which is maintained at some given voltage with respect to an ambient space plasma. Also presented is a simulation of the interaction of a plasma with a dielectric disk which has a smaller conducting disk centered on top of it. The purpose of this simulation is to study the causal mechanisms of two experimentally–observed effects, the "pinhole effect" and the "area effect" observed in spacecraft–charging experiments.

The simulation model uses the particle–in–cell plasma simulation technique, with cylindrical geometry assumed. The electrostatic potentials are calculated using successive over–relaxation. The dielectric properties of secondary electron emission, electron backscattering and charge–sticking are included.

The results presented in this work include plots of the electrostatic potential as a function of position, surface voltage profiles, and current–voltage characteristics. Also presented are comparisons of the calculated results with experimental results.

While this work does not indicate whether secondary electron emission and backscattering comprise the entire mechanism producing the pinhole and area effects, it is shown that their effect is such as to significantly affect the current–voltage characteristics, with the result that the calculated characteristic curves display the same qualitative behavior (i.e., they show the "S-shape") as the experimental curves.

A calculation of the drainage current as a function of dielectric area gives qualitatively the same results as the experimental methods: the current is found to increase rapidly as a function of area for small dielectric area, with a less–rapid increase for larger dielectric area. This is shown to be due to the effect of secondary emission electrons and backscattered electrons from the dielectric surrounding the current collector.