(No122)

The particular feature of fractional derivative is non-locality: (7) involves a convolution product, and therefore, the fractional derivative of g(x) depends on the overall shape of the function and not only on its local slope or curvature. The memory effect is therefore directly included in this mathematical tool. The transport dispersive features may then be introduced easily, replacing in the normal transport equations (describing diffusion, conduction, hopping) the classical time derivatives by fractional ones. It is not possible however to develop here in details the important question of the application of fractional calculus to charge transport, which is treated in many recent papers [21].

V. Some Aspects Relevant to Spacecraft Charging

Incorporating these multiple aspects of the material complex behavior in a useable software tool is a challenge for the engineer, and might seem out of reach. However, a few simple and practical ideas may be deduced from this panorama of electrical conduction models.

First, let us underline that the memory effect of the insulators as it has been described here, linked to their disordered structure, is the main cause for the complex transient behaviors observed in charging experiments on space materials. Aging due to irradiation will also occur after a given time, but the dynamical features of the trapping processes have first to be analyzed, as has been shown by several works [4][22].

Second, one of the main difficulties that arise when trying to adapt the concepts developed here to practical situations encountered in space is that radiation-induced conductivity or bulk photoconduction are essentially driven by recombination processes. The present description of the material behavior is essentially devoted to unipolar conduction. Part of the transient RIC features may be treated by decoupling the hole and electron densities, but the introduction of recombination will in the end introduce a nonlinear element, recombination being proportional to a product of free charge density of one polarity by the charge density of the opposite polarity.

The use of numerical simulations seems the only possible way to deal with this complexity. However, the number of parameters that may be involved is important, and the identification process may not be satisfactory with a limited amount of experimental data.

From this perspective, the development of limited experimental software tools, incorporating one by one the different aspects of the complexity, coupled with a good knowledge of the possible physical processes involved, may be an important step towards future operational software for the engineer.

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