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Density of State Models and Temperature Dependence of Radiation Induced Conductivity

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Abstract

Radiation induced conductivity (RIC) occurs when incident ionizing radiation deposits energy and excites electrons into the conduction band of insulators. The increased number of charge carriers, and hence the magnitude of the enhanced conductivity, is dependent on a number of factors including temperature and the spatial and energy dependence and occupation of the material's distribution of localized trap states within the band gap—or density of states (DOS). Expressions for RIC in terms of the filling of the DOS up to an effective Fermi level were largely developed by Rose [*RCA Review*, 1951], and were extended by Fowler [*Proc. of the Royal Soc. of London A*, 1956], Vissenberg [*Phys. Rev*., 1998], and others.

A general discussion of the DOS of disordered materials can be given using two simple distributions, one that monotonically decreases below the band edge and one that shows a peak in the distribution within the band gap. Three monotonically decreasing models (exponential, power law, and linear), and two peaked models (Gaussian and delta function) are considered, plus a limiting cases with a uniform DOS for each. Variations using the peaked models are considered, with an effective Fermi level between the conduction mobility edge and the trap DOS, within the peaked trapped DOS, and below the peaked distribution.

Equations for RIC are typically expressed in a power law form in which the radiation dose rate (a measure of the energy deposited per unit time and unit mass) raised to the power Δ, with a proportionality constant, k_{RIC}. Expressions are presented for both k_{RIC} and Δ, as temperature-dependent material parameters for each of the DOS models described above. The models are compared to measured RIC values over broad temperature ranges for polyimide, polyethylene, and disordered silicon dioxide.

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