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Charge Transport and Electron Emission of Disordered Materials: Extensions of the Walden-Wintle Model for Charge Injection with Electron Beams

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Abstract

We have extended the Walden-Wintle model for charge injection and transport through highly disordered insulating materials to include charge injection with a charged particle beam. The original model is applicable to charge injection in a dielectric material from a pair of electrodes in a parallel plate geometry. It provides a versatile approach to predict the time-dependent current at a rear grounded electrode, as the injection current density evolves over time with the development of a space charge barrier near the injection electrode. The Walden-Wintle model has been applied to many standard cases including Fowler-Nordheim injection, Schottky injection, space charge limited injection, and various tunneling mechanisms. Our new model modifies the approach to include electrode-less charge injection via a charged particle beam, along with concomitant effects for the injection current, surface voltage, and electron emission as a charge is built up in the insulator. The approach is equally valid for near-surface injection and for bulk injection of both non-penetrating and penetrating radiation. The results are based on our dynamic emission model for yields dependent on accumulating charge in both the positive and negative charging regimes.

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