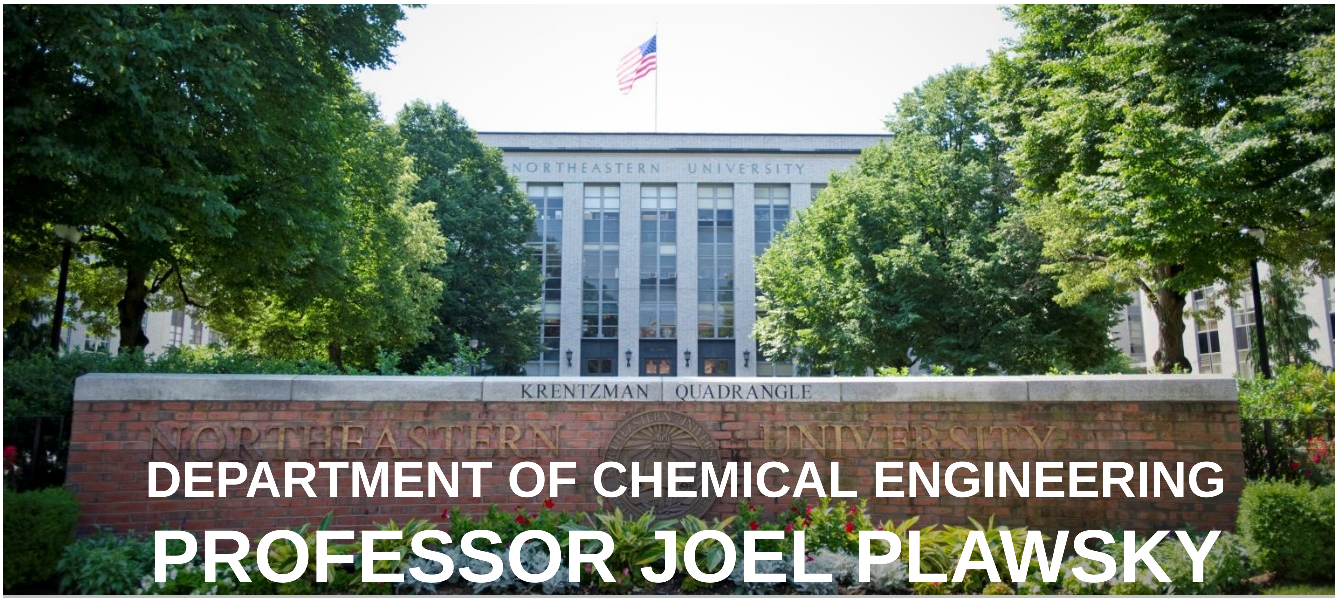

DEPARTMENT OF CHEMICAL ENGINEERING

PROFESSOR JOEL PLAWSKY

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Modeling Dielectric Breakdown and Predicting IC Device Lifetime

Wednesday, November 2
105 Shillman Hall
11:45am-1:00pm

Sponsored by the Department of Chemical Engineering

Several empirical, algebraic models are commonly used to predict the failure of dielectric materials, but there exists a dispute over which model provides the most accurate prediction of device lifetime under operating conditions. As a result, there is a need to transition from the use of empirical models to a model built primarily on theory. We have developed a charge transport model to predict the device lifetime of dielectric materials in integrated circuits. The model is based on electron transport and donor-type, defect (trap) formation. Breakdown occurs when the defect concentration reaches a critical density, resulting in electron tunneling and the emptying of positively charged traps. An enhanced local electric field at the dielectric boundary lowers the barrier for electron injection into the dielectric, causing a positive feed-forward failure. The charge transport model replicates experimental I-V and I-t curves, capturing the leakage current and its decay at early stress times and the rapid current increase at failure. The model is based on field-driven and current-driven failure mechanisms, and uses a minimal number of parameters. All the parameters have some theoretical basis or have been measured experimentally, and are not directly used to fit the slope of the time-to-failure versus applied field curve.

Despite this simplicity, the model is able to accurately predict device lifetime for three different sources of experimental data, replicates the features of several of the empirical models normally used, can be used to match experimentally measured failure statistics and even predicts a reasonable end for dielectric scaling.

Joel Plawsky is Professor and Head of the Howard P. Isermann Department of Chemical and Biological Engineering at Rensselaer Polytechnic Institute. He received his BS from the University of Michigan and his MS in Chemical Engineering Practice and ScD from MIT. Following graduate work, he spent two years at Corning, Inc working on optical fiber technology and developing novel photosensitive glasses. He then changed careers and moved to RPI as an assistant professor. Joel research is in the area of applied transport phenomena and most of that work has involved thin films of one form or another.

Joel has run 7 experiments on the Space Shuttle and ISS on topics ranging from biofilm formation to interfacial phenomena within a miniature heat pipe. His group won the 2015 ISS R&D award for their heat pipe experiment. Joel has worked for a number of years with the electronics and photonics industry fabricating, characterizing, and modeling the performance of a variety of thin, solid, dielectric films used to enhance the output of LED's and as dielectric materials in integrated circuits.

Joel is the author of Transport Phenomena Fundamentals, 3rd ed from CRC Press and is a Fellow of AIChE and ASME.