Bio: Elyse Rosenbaum is the Melvin and Anne Louise Hassebrock Professor in Electrical and Computer Engineering at the University of Illinois Urbana-Champaign. She received a Ph.D. in electrical engineering from University of California, Berkeley. She is the director of the NSF-supported Center for Advanced Electronics through Machine Learning (CAEML), a joint project of the University of Illinois, North Carolina State University, and Penn State. Her current research interests include CDM-ESD reliability, ESD-robust high-speed I/O circuit design, compact modeling, optimization of heterogeneously integrated system-in-package, explainable models of analog circuits, and inverse models for device design.

Dr. Rosenbaum has authored or co-authored over 200 technical papers; she has been an editor for IEEE Transactions on Device and Materials Reliability and IEEE Transactions on Electron Devices. She served as the General Chair of the 2018 International Reliability Physics Symposium. Dr. Rosenbaum was the recipient of a Best Student Paper Award from the IEDM, an Outstanding Paper Award and 2 Best Paper Awards from the EOS/ESD Symposium, a Technical Excellence Award from the SRC, an NSF CAREER award, an IBM Faculty Award, and the ESD Association's Industry Pioneer Recognition Award. She is a Fellow of the IEEE.

Finalized title: Measurement Challenges Impeding the Verification of ESD Compact Model Accuracy and Generalizability

At this point in history, most ESD specialists believe that the physics underlying ESD device behavior are understood and can be expressed in the form of a compact model. Optimizing and validating those models remains a challenge and will be the main focus of this presentation. However, for the benefit of non-ESD specialists, the talk will start with a brief introduction to CMOS ESD protection devices and their behavior.

Ordinarily, compact model parameter extraction utilizes DC and C-V measurement data; in some cases, the dataset may be augmented by S-parameter data. All those measurements use common laboratory equipment, and consistent results are obtained in different laboratories.

Unfortunately, the I-V characteristic of an ESD protection device cannot be obtained from a DC measurement because the current levels of interest are so large that the device would suffer thermal failure during the measurement. Instead, pulse I-V measurements are performed using a specialized instrument referred to as a transmission line pulse (TLP) tester. The transient response of the device may be dominated by non-quasi-static effects such as forward recovery, requiring that the corresponding model parameters be extracted from transient measurements. The slew rates of interest may be as large as 10^{10} A/s, and accurate capture of the device response requires a high-bandwidth and well-characterized readout chain, composed of a voltage probe, cables, connectors and oscilloscope. Because the stimulus is a single current pulse—little more than an impulse—the oscilloscope must have a very high sampling rate.

Model parameter optimization is an iterative process that involves repeated calls to a circuit simulator. The accuracy of the model fitting is limited by the fidelity of the representation of the stimulus, e.g., the TLP tester.

An ESD compact model should provide accurate simulation results when the device is embedded in a larger circuit, where the wiring and even the layout may be different from those of the test structure used for model parameter extraction. The high slew rate of the ESD current pulse leads to voltage drops in the BEOL wiring inductance, while the high amplitude of the current and the resultant IR drops in the BEOL wiring lead to nonuniform conduction across a very large protection structure. If those effects are not accounted for during model parameter extraction, the model will not generalize to other layouts.

Additionally, model validation that relies solely on TLP measurement data does not establish that the model correctly predicts the device transient response to anything other than unipolarity square pulses. I will review progress on meeting this challenge and indicate what additional work is needed.