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# DATA-DRIVEN DEVICE AND CIRCUITS MODELS

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## MINISYMPOSIUM

Circuit simulations, often referred to as Spice simulations, are foundational to modern circuit design. Since their inception in the 70s, the prevalent approach in Spice simulations has been to build the underlying circuit models from compact analytic device models. However, this approach is prone to two distinct types of bottlenecks. The first one stems from the fact that traditional development of compact device models is largely a manual, time intensive effort that requires highly skilled experts with combined knowledge of solid-state physics, circuit design, model calibration, and numerical analysis. As a result, development of these models often lags behind the initial design stages of microelectronics circuits. The second, performance bottleneck arises when one attempts to scale traditional Spice simulations to large circuits comprising millions of components. Since compact models for these components can be quite complex on their own, together, they can lead to very large nonlinear systems of equations that are very expensive computationally. This hinders utilization of Spice simulations in multi-query design analysis tasks such as quantifications of the margins of uncertainty, reliability, and optimal design of circuits.

Data-driven approaches such as system identification, model order reduction, non-intrusive operator inference, dynamic mode decomposition, and deep neural network regression, to name a few, have the potential to overcome these bottlenecks by (i) providing the means to automate the development of compact semiconductor device models, either directly from data or from full-featured TCAD (technology computer-aided design) device models, and (ii) enabling the development of computationally efficient surrogates for full-featured circuit models. This session will focus on recent advances in the application of these ideas, ranging from purely data-driven to gray box and physics-informed machine learning approaches to the agile development of computationally efficient models for devices and circuits.