THE UNIVERSITY OF TENNESSEE KNOXVILLE

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A Generalized Workflow for Creating Machine Learning Powered Compact Models of Multi-State Devices

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Outline

- Motivation – Why Compact Models?
- ML-Powered Compact Modeling Framework
- Results & Analysis
- Outlook
- Comments & Conclusion

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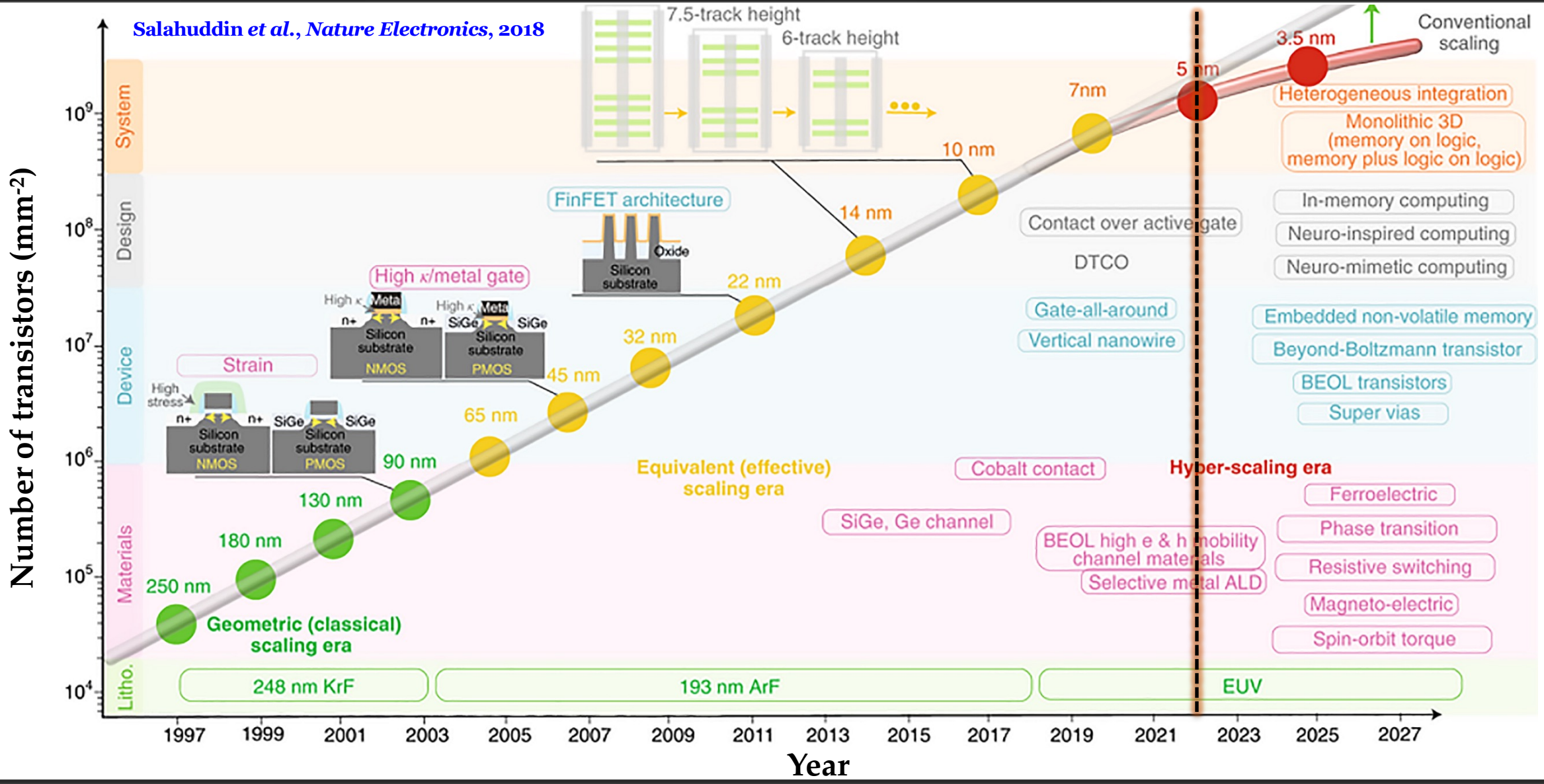
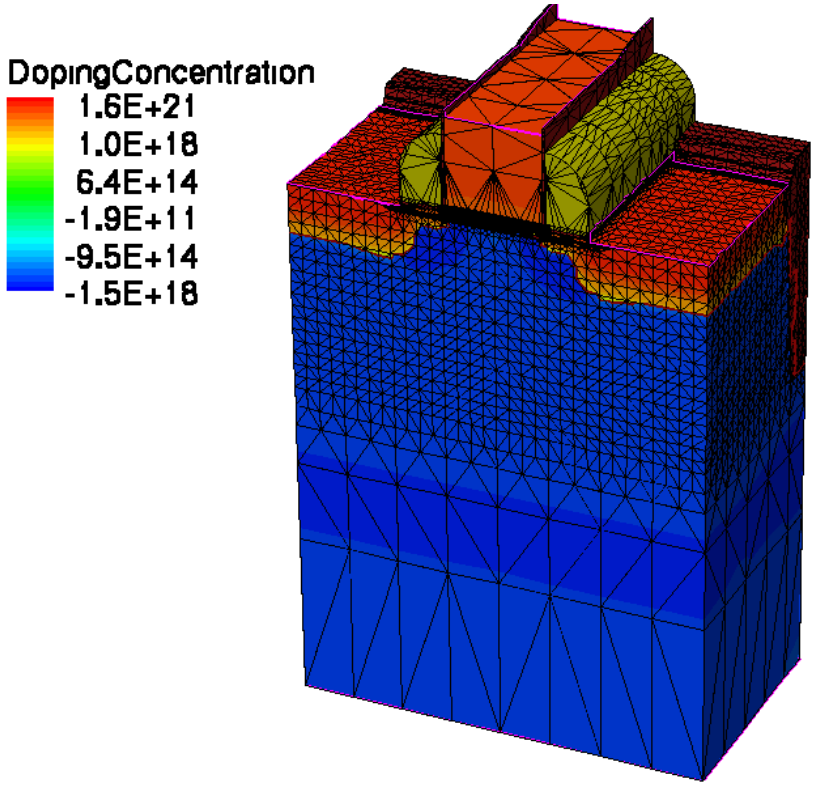
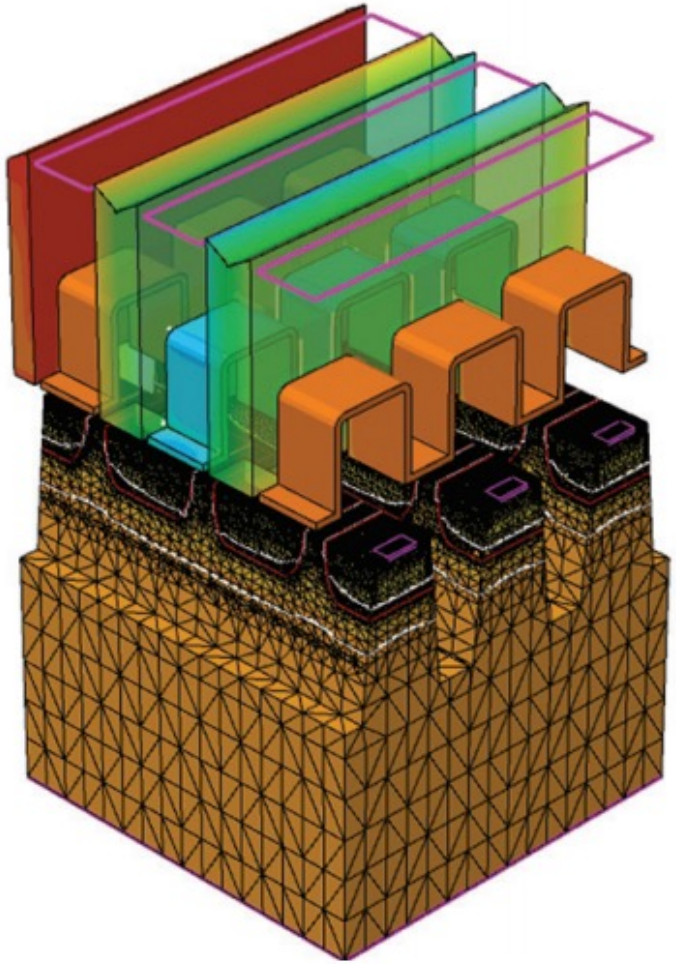
Technology Trends



Device Modeling using Commercial Numerical Tools



CRC Electronic Design Automation
for IC Handbook, Chapter 24

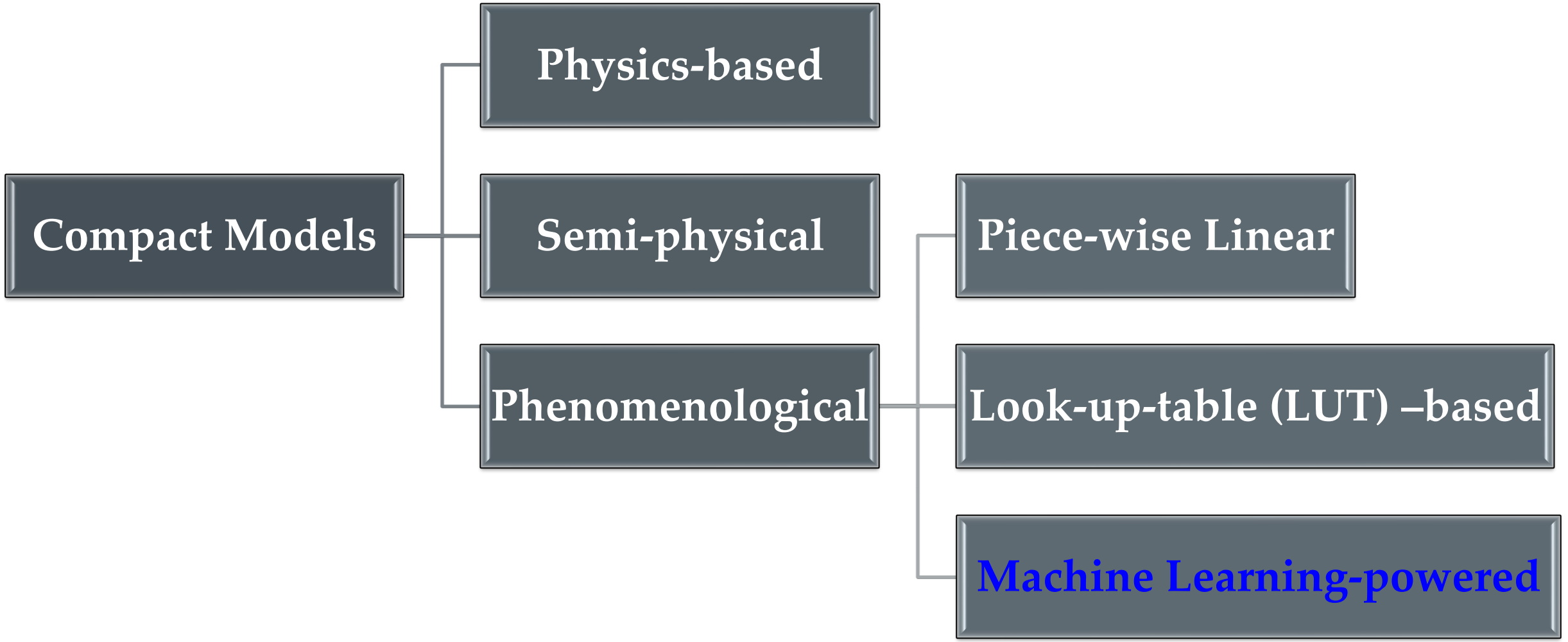


Memory cells simulated in TCAD Sentaurus
Credit: Synopsys

Questions

- How can we test novel device ideas?
- Will these novel devices properly work in circuits?
- How can we estimate their system-level benefits?

Categories of Compact Models



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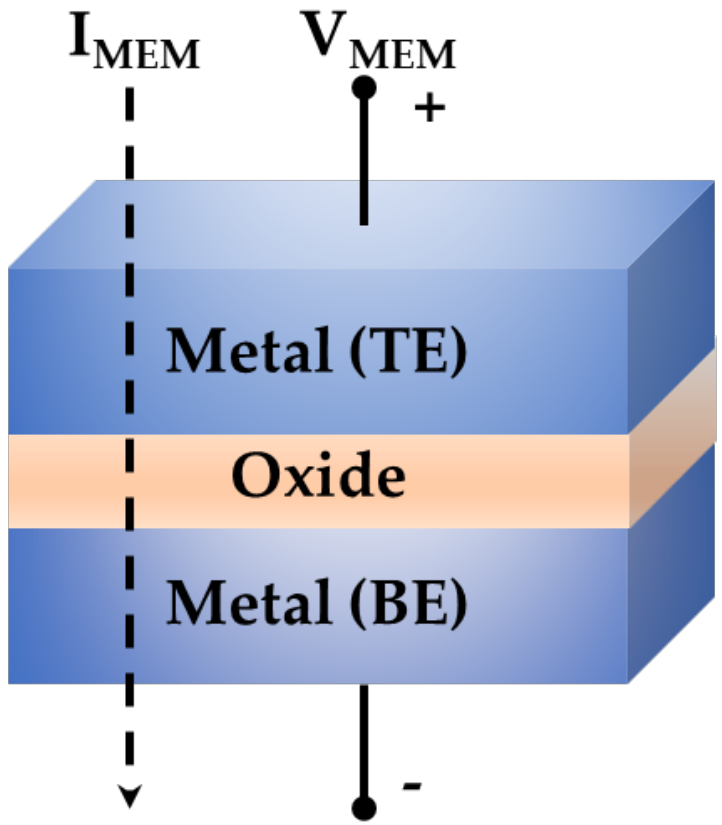
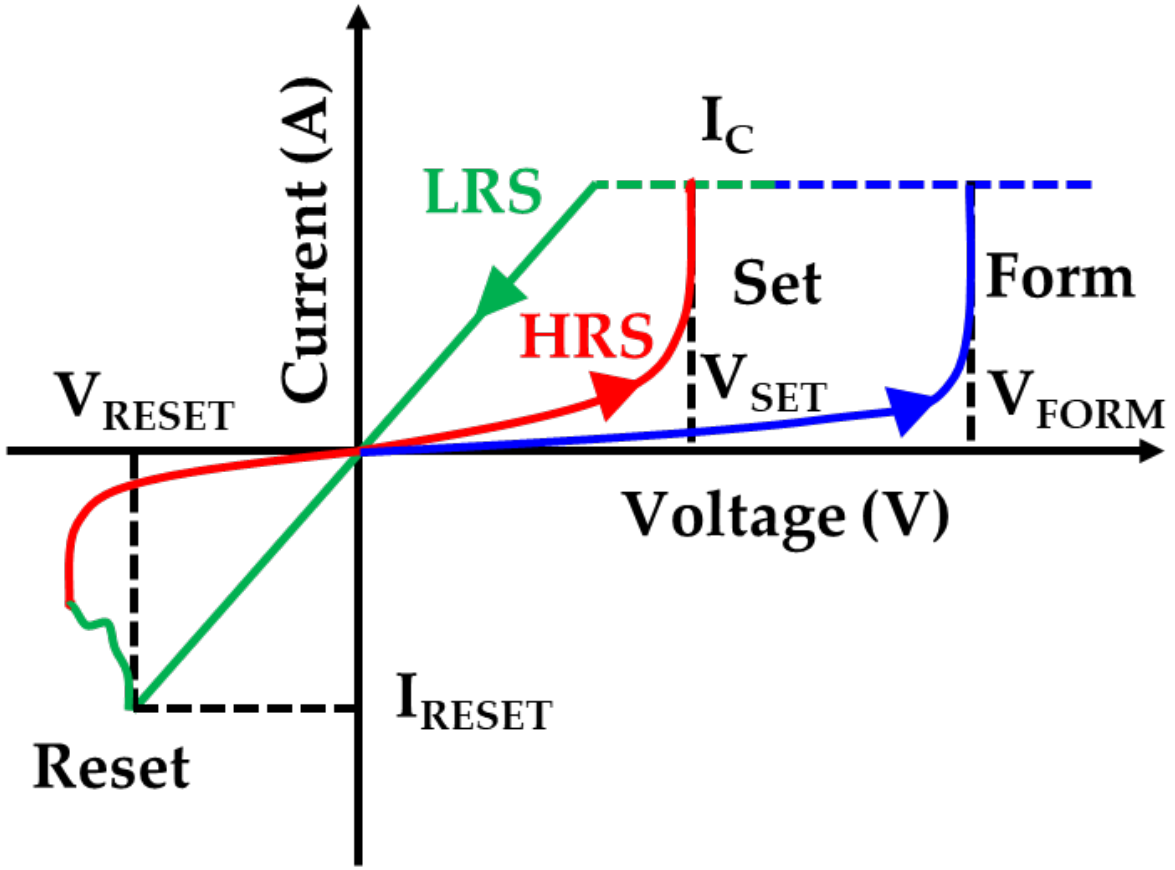
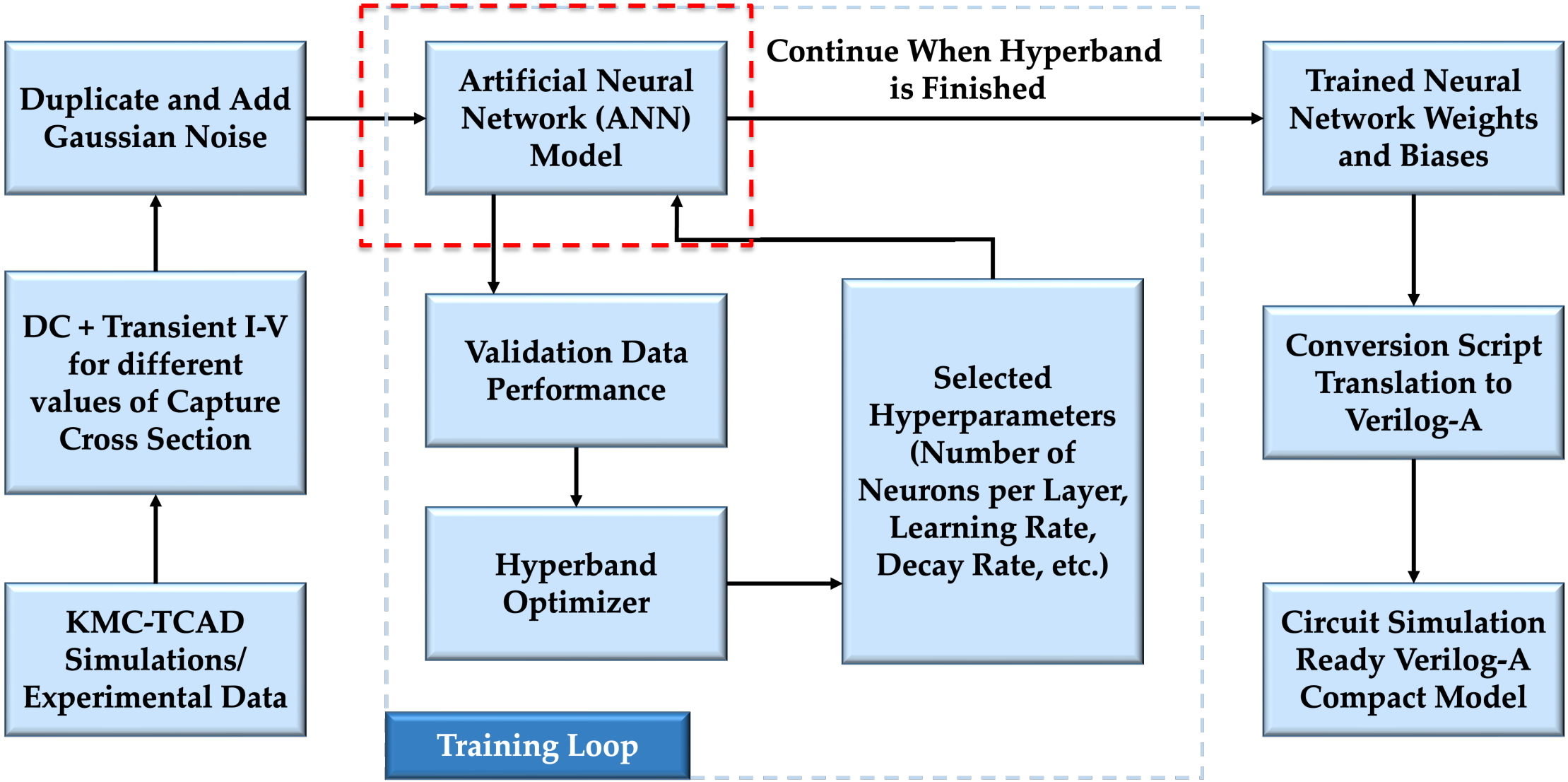
Memristor: A Multi-State Device

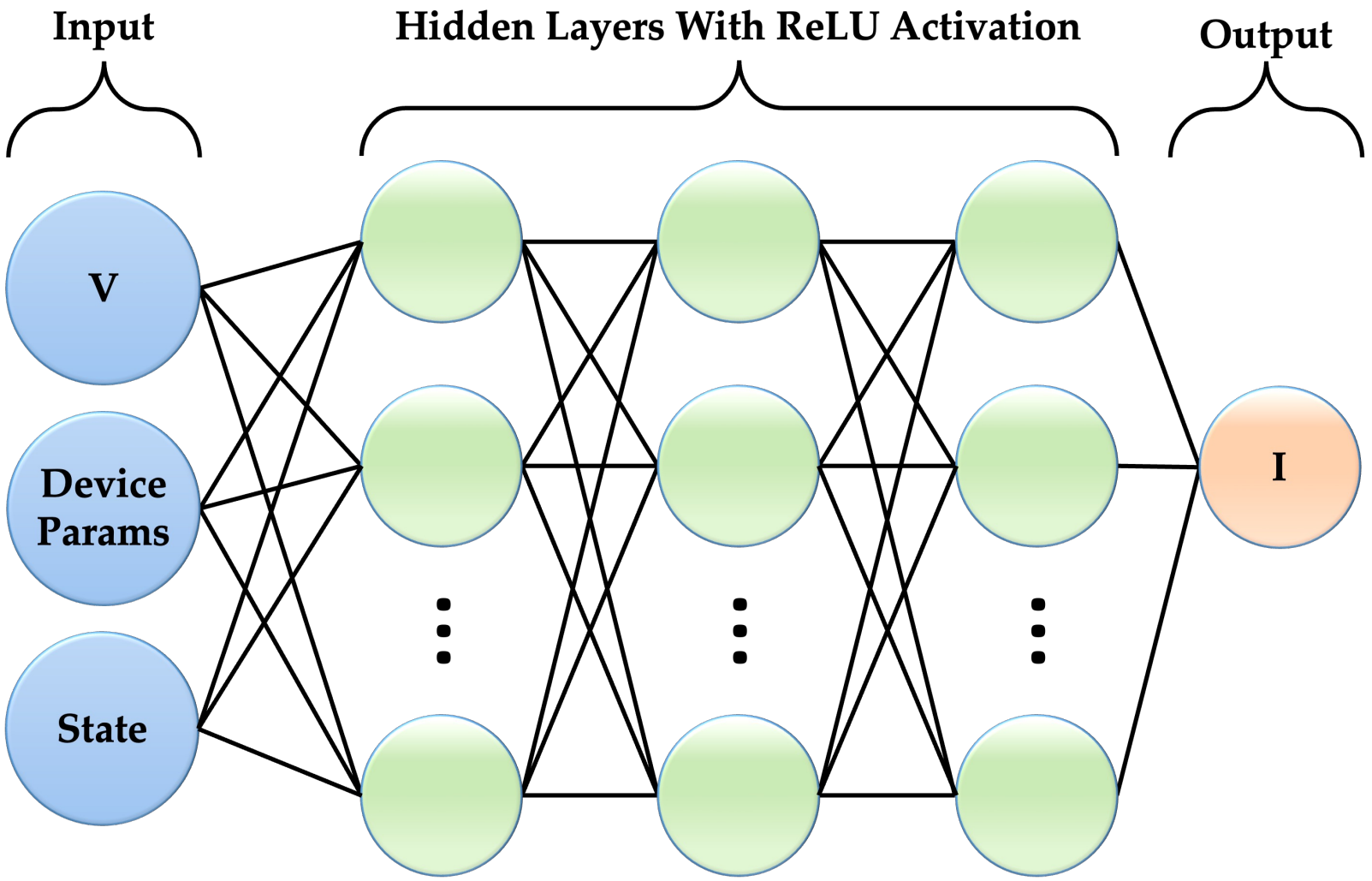




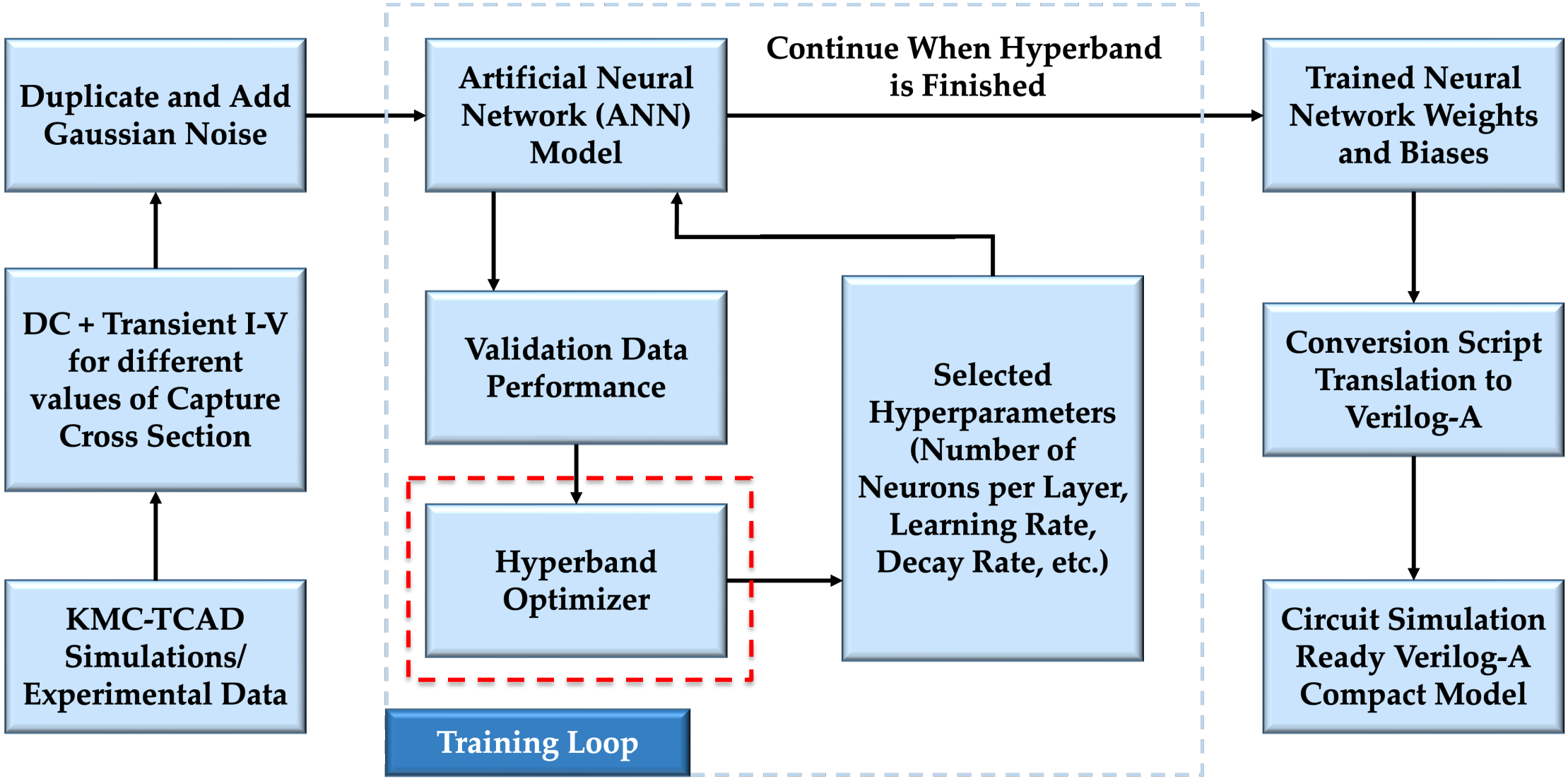
Memristor Modeling Approach



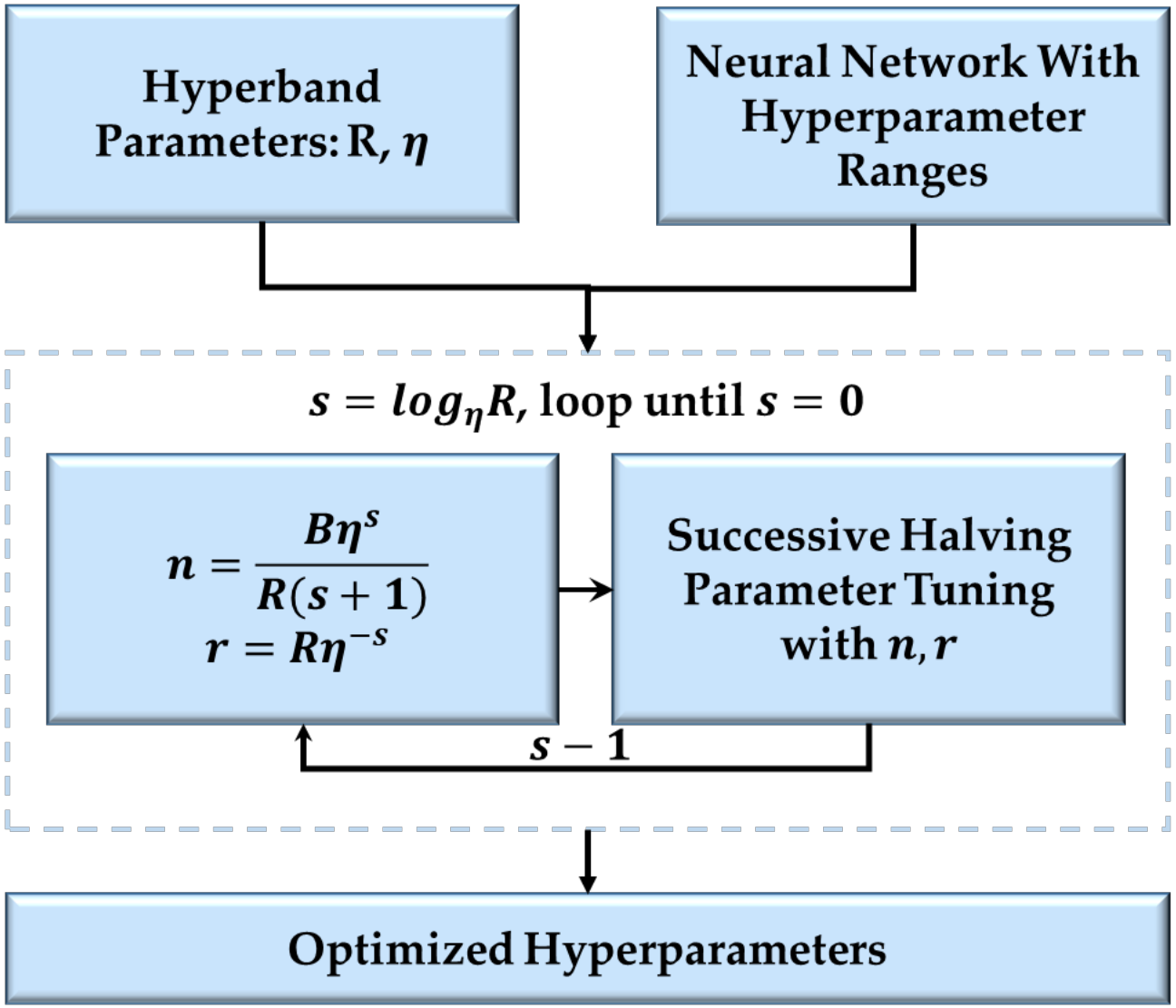
Neural Network



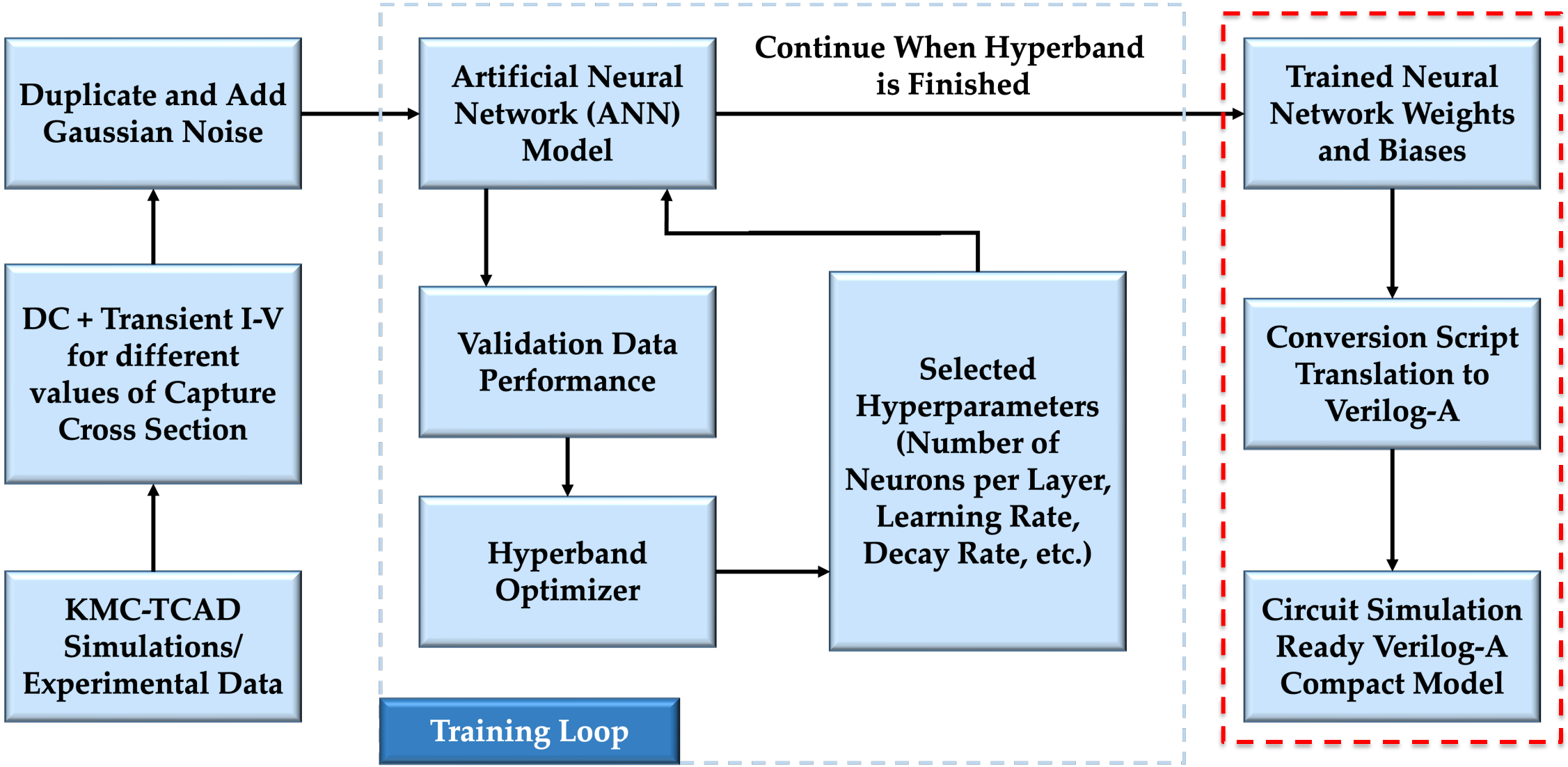
Memristor Modeling Approach



Hyperband Algorithm



Memristor Modeling Approach



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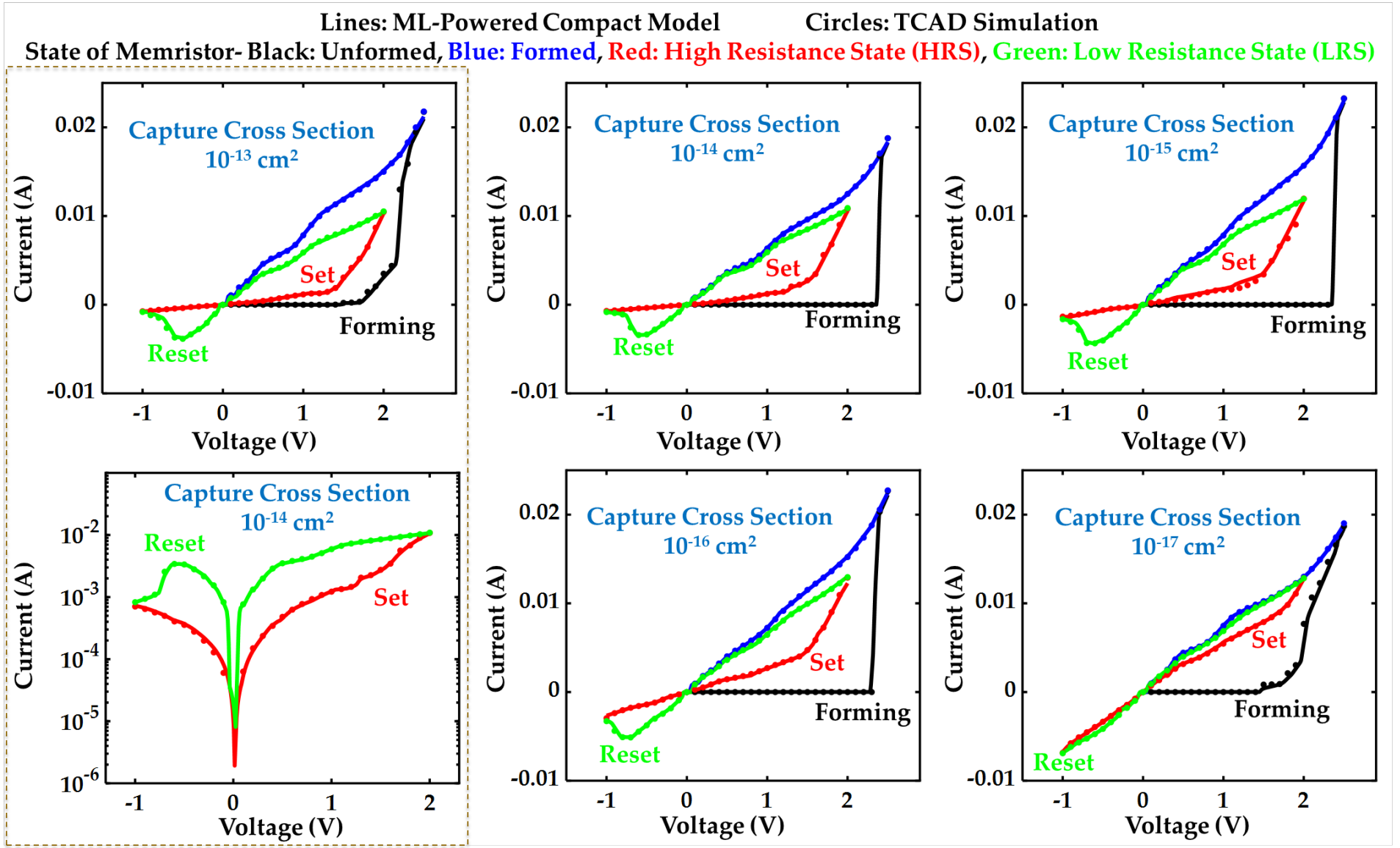
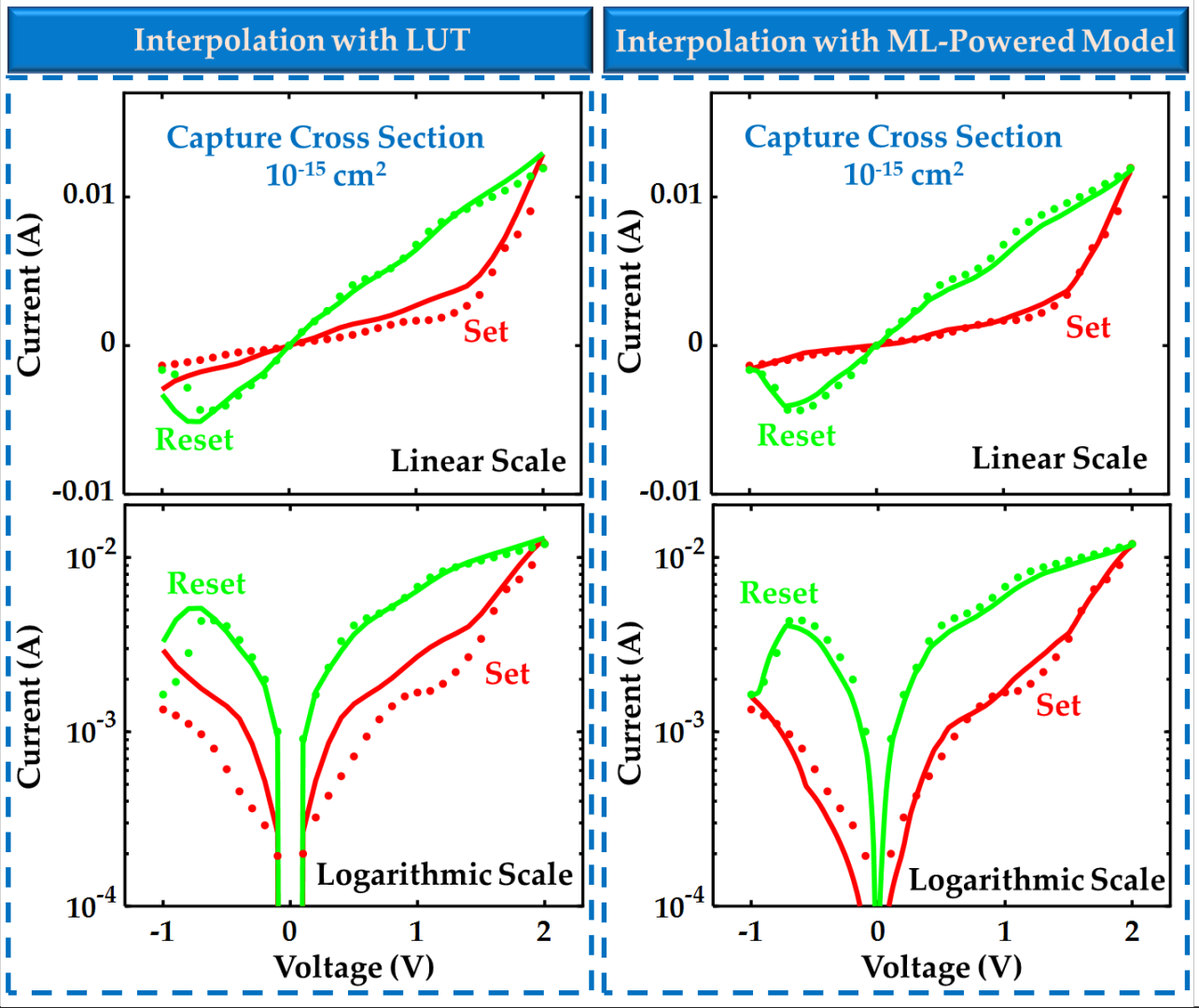
Model Testing



Model Testing

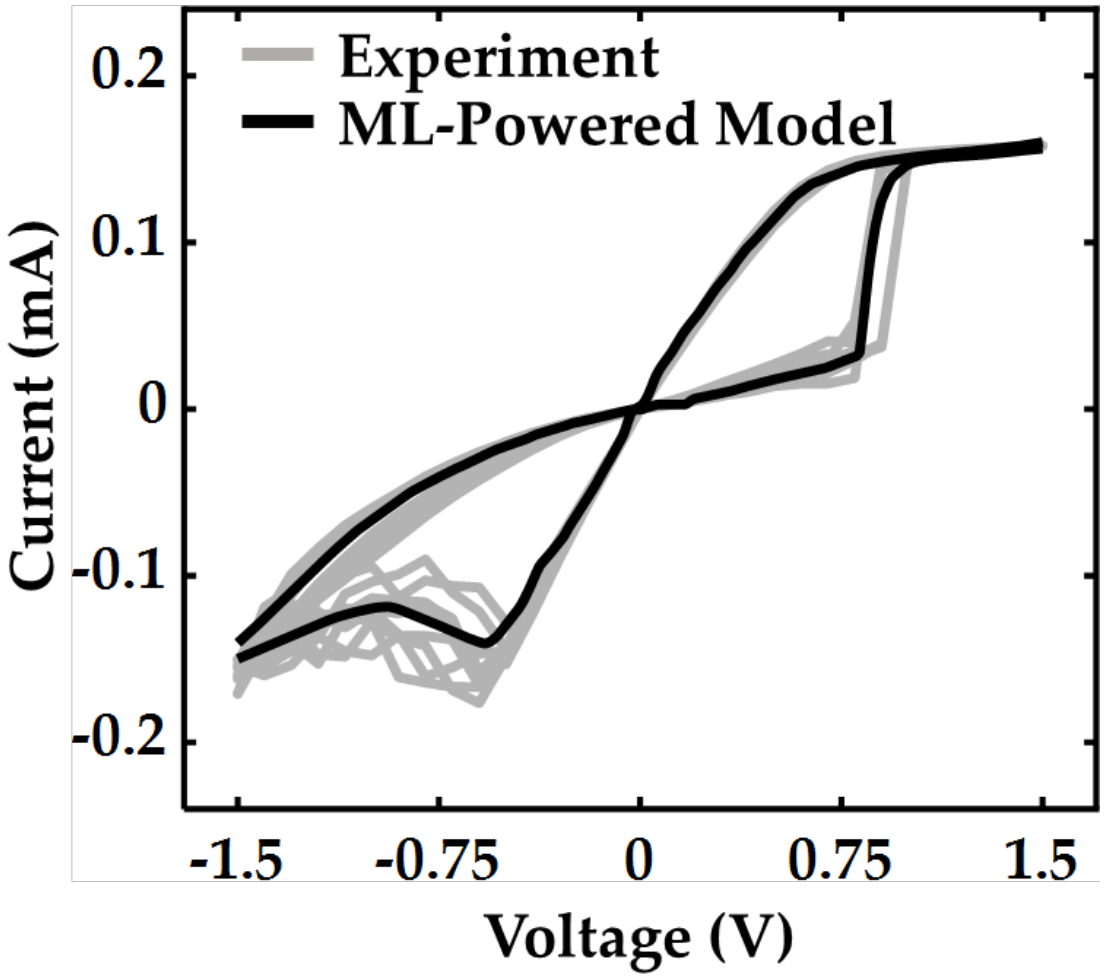
Lines: Model with Interpolation Circles: TCAD Simulation
State of Memristor- Red: HRS, Green: LRS



Interpolation Performance of Our Model and Lookup Table-based Model

Method	LRS		HRS	
	RMSE	R^2	RMSE	R^2
Our Model	0.000484	0.990896	0.000323	0.988363
Lookup Table	0.000764	0.975318	0.000957	0.937633

Model Testing



$$\text{RMSE} = 8.5977 \times 10^{-6}$$

$$R^2 = 0.99248$$

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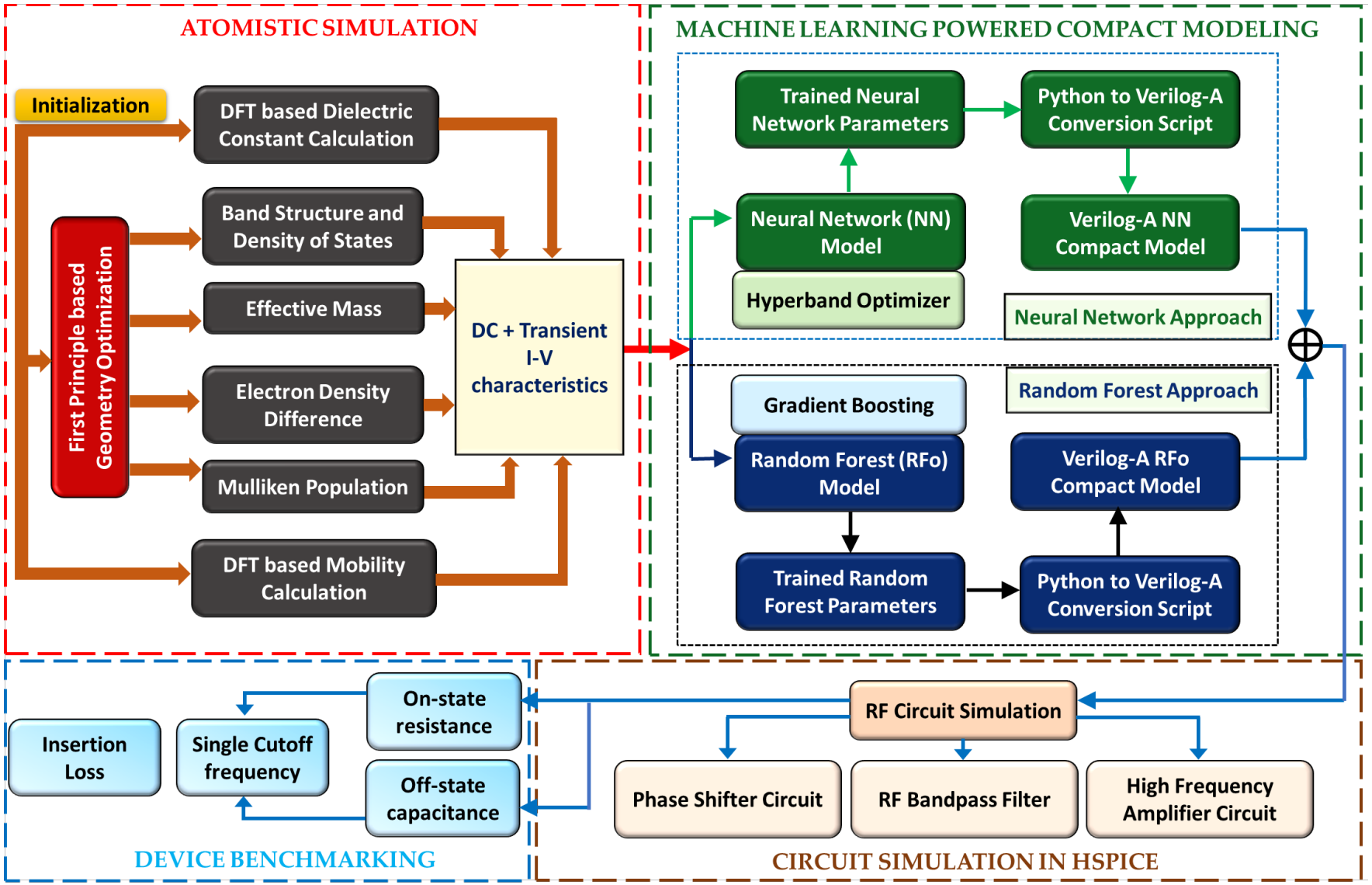
Work in Progress: Atom-to-Circuit Compact Modeling



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Remarks

- We generalize the process of creating ML-based compact models for multistate devices while reducing the amount of training data required.
- Our process of adding gaussian noise to the training data simulates having multiple devices in the dataset, reducing the amount of data required.
- Duplicating and adding noise reduced the RMSE of the testing data by 18.8%.
- Our ML-based framework prepares a circuit-compatible compact model to facilitate system-level simulations.

Acknowledgement

Sponsor

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Thank You

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