

1. Title: Simulation of Second Order Effect Signatures of Integrated Circuits

2. Individual Sponsor:

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3. Academic Area/Field and Education Level: physics, electrical engineering (MS or PhD)

4. Objective: Develop physics-informed simulation and modeling methodologies to predict selected second-order-effect signatures of integrated circuits from available design files and related device information. The goal is to assess whether simulated signature predictions and associated confidence bounds can reduce dependence on golden reference devices in second-order-effect assurance testing.

5. Description: Second-order-effect measurement systems have shown sensitivity to subtle physical differences within integrated circuits, suggesting potential utility for detecting counterfeit microelectronics devices. In this context, first-order effects refer to the intended functional behavior of an integrated circuit, while second-order effects refer to secondary physical responses, such as subtle electrical, electromagnetic, thermal, or dynamic signatures, that arise from the circuit's implementation, materials, layout, and operating conditions. Existing approaches often rely on comparison against a known-good golden device, introducing assurance risks tied to assumptions about its provenance, integrity, and representativeness. This topic aims to investigate whether second-order-effect signatures can be predicted and modeled through physics-informed simulations based on available design files, including GDSII, SPICE models, netlists, and related information for a device under test. The research will explore simulation methodologies and modeling assumptions needed to predict these signatures, evaluate signature sensitivity to design and physical parameters, and assess the confidence with which simulated signatures can support assurance decisions. Successful modeling of second-order-effect signatures may reduce the requirement for golden reference devices, support validation of digital twin models of target devices and systems, and advance the design of secure systems.

6: Research Classification/Restriction: CUI/ITAR

7. Eligible Research Institutions: All

Keywords: Second Order Effects, Side Channel Analysis, Digital Twin, Modeling, Simulation, Digital Engineering, Integrated Circuits

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