TEXAS INSTITUTE FOR ELECTRONICS

The University of Texas at Austin

TNC Research Activities Update

Ted Moise, University of Texas at Dallas

DARPA NGMM Summit

October 27, 2025

Outline

- Mission-aligned Academic Research
- Key Academic Research Thrust Areas
  - Heat Removal Optimization and Characterization
  - 3DHI Reliability Stress and Failure Analysis
  - 3DHI Assembly Design Kit and Modeling
  - Manufacturing AI
  - Ultra-low Power Edge Computing
- Conclusions

Mission-aligned Academic Research

- TIE's NGMM Academic research partners will contribute to TNC's success by providing R&D expertise in key thrust areas aligned with NGMM program goals.
- Funding for a variety of academic researchers will enhance the fundamental capabilities of the center.

Heat Removal Optimization and Characterization Research

Goal: For mixed-material 3DHI microsystems, (i) develop validated heat transport models and (ii) create advanced thermal management solutions.

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Develop best-in-class passive thermal solution within the 3DHI stack and integrable into 3D-ADK

Georgia Institute of Technology

Thermal modeling and experimental demonstration of fluidic cooling for 3DHI through micro-pin array

TEXAS A&M UNIVERSITY
Engineering

Transient thermal characterization of 3DHI configurations, and supporting materials, composites characterization via Time and Frequency Domain ThermoReflectance (TDTR and FDTR) measurements

PennState
College of Engineering

Integrated thermal management for RF and Compact Power Converter devices

3DHI Reliability Stress and Failure Analysis Research

Goal: For mixed-material 3DHI microsystems, develop modeling and experimental validation capabilities to understand failure modes and design for enhanced reliability.

3DHI metrology and modeling framework that qualifies representative interfaces and predicts CPI (chip-package interaction) for thermomechanical reliability

3DHI thermo-mechanical design, damage mechanics, failure prediction, and reliability analysis

Multiscale and Multiphysics computational modeling and experimental characterization for fracture and electromigration failure risk assessment in complex packages

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3DHI Assembly Design Kit and Modeling Research

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Goal: For mixed-material 3DHI microsystems, (i) establish validated models of thermal and mechanical behavior in support of the development of TNC's 3D-ADK and (ii) create open-access 3DHI EDA infrastructure.

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Development of 3D-ADK in terms of thermomechanical properties of interfacial materials, die size, interlayer thickness, and interconnect density

TEXAS A&M UNIVERSITY Engineering

Measurement of key multiscale thermomechanical properties and characteristics of 3DHI interfaces

Georgia Institute of Technology

Develop and conduct physics-based process mechanics simulation to predict warpage, stress/strain evolution, and to validate against experimental data

PennState College of Engineering

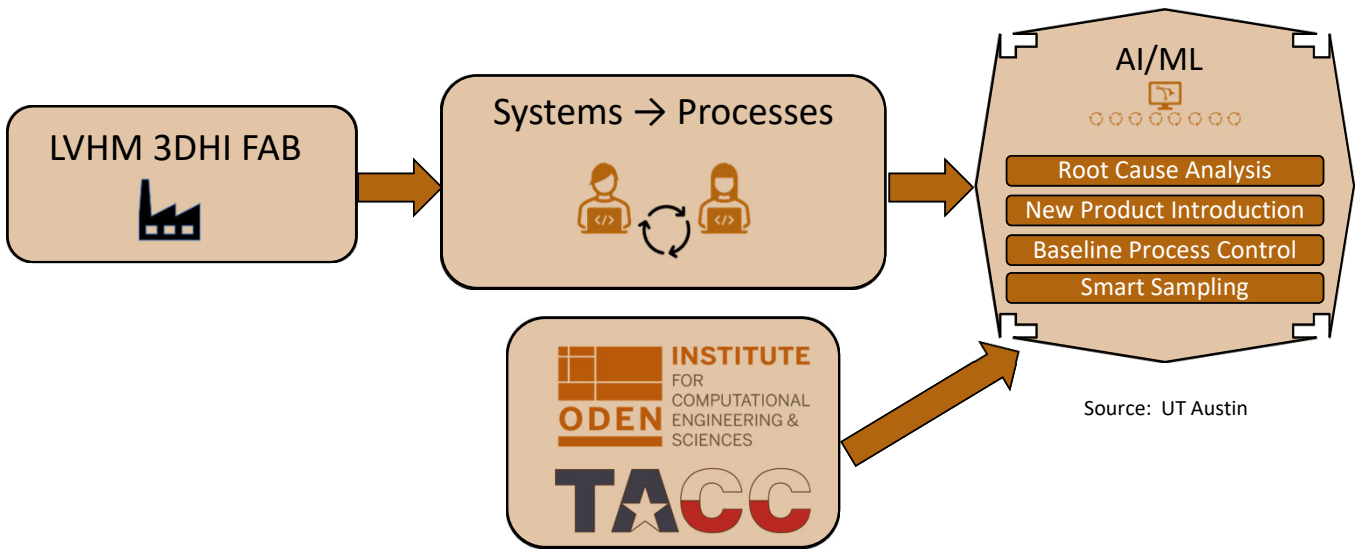
Achieve predictive modeling, optimization, quantification, inverse design, and composition of Digital Twin components

UC San Diego UCLA

Open 3D-ADK standardization and open-access 3DHI EDA infrastructure

Manufacturing AI for LVHM 3DHI Fab Research

Goal: Enhance yield and productivity of a Low-volume, High-mix (LVHM) 3DHI foundry by implementing contextual AI enabled by integrating model-based and model-free approaches.



Source: UT Austin

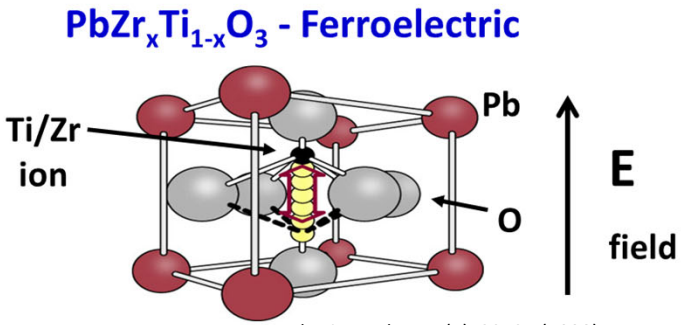
Manufacturing AI spanning several frameworks including model-based and model-free approaches towards achieving the desired process control

Ultra-Low Power Edge Compute Research

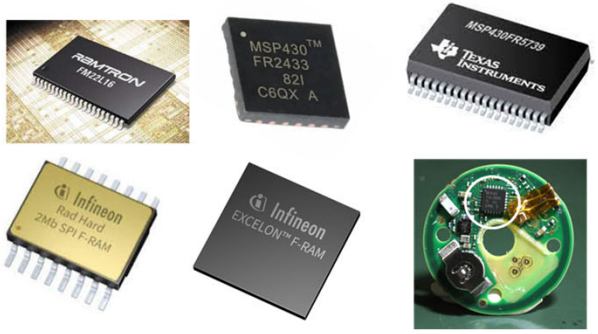
Goal: Explore low-power memory materials for 3DHI sensor architectures that require embedded memory and compute with high-density 3D interconnects to enable edge AI.

UT Dallas RICE Berkeley UNIVERSITY OF CALIFORNIA

Develop ultra-low power non-volatile edge compute technology using ferroelectric capacitors



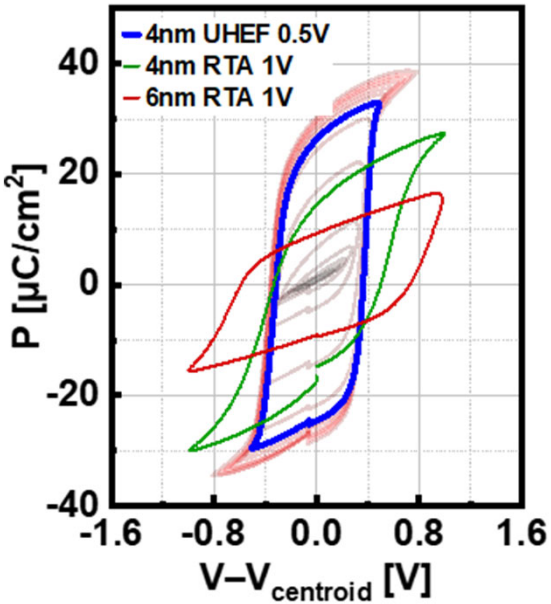
Physics Today 51 (7), 22–27 (1998)



Ramtron, Texas Instruments, Infineon, YouTube

- Lowest-power, fast-write **non-volatile memory (~$500M/yr)**
  - Enables fast data logging, code updates, ULP operation, etc.; 1.5V operation; 1ns intrinsic switching
  - Used in ULP biomedical, industrial/automotive data logging, space, and micro-controller applications, etc.
  - Texas Instruments program led by **Ted Moise**; Fundamental materials development, oxide electrodes for zero-fatigue led by **Ramesh Ramamoorthy**
- **NGMM Envisioned Advancements**:
  - 10x NVM power reduction (~0.5V operation)
  - Epitaxial ferroelectrics with larger signal margin for improved process robustness and reliability

Ultra-Low Power Edge Compute



Source: UT Dallas

Epitaxial $BaTiO_3$

RICE

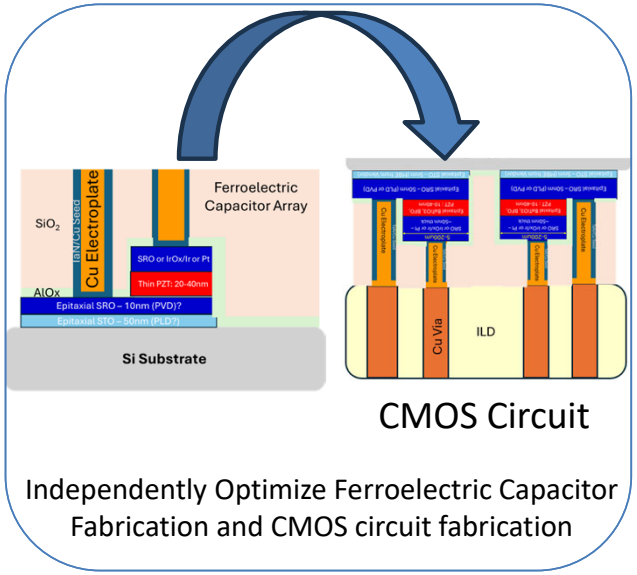
Epitaxial $BiFeO_3$

Berkeley
UNIVERSITY OF CALIFORNIA

Epitaxial $PbZr_xTi_{1-x}O_3$

UT DALLAS

3DHI Co-Integration



Independently Optimize Ferroelectric Capacitor Fabrication and CMOS circuit fabrication

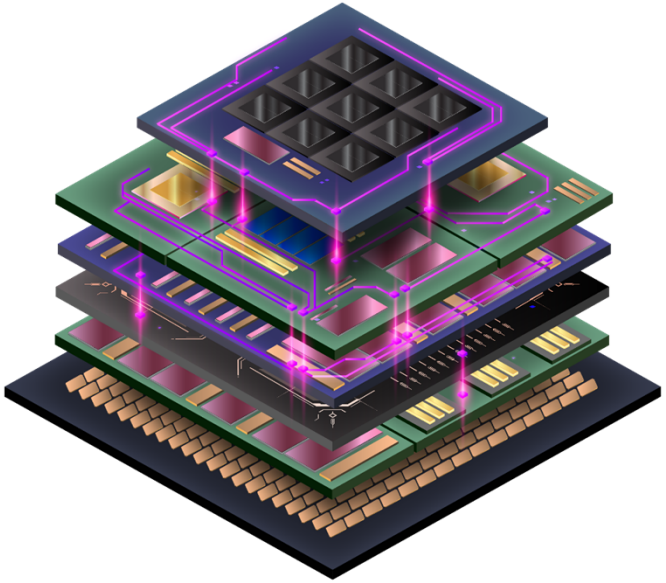
Source: UT Dallas

Summary

- Mission-aligned scientific research bringing best-in-class academic talent to address key gaps in mixed-materials 3DHI for:
  - Heat Removal Optimization and Characterization
  - 3DHI Reliability Stress and Failure Analysis
  - 3DHI Assembly Design Kit and Modeling
  - Manufacturing AI
  - Ultra-low Power Edge Computing

- Through postdoctoral funding to solve these research problems, NGMM also creates a pipeline of next-generation of advanced-packaging technology leaders

THANK YOU



For more information, visit:
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