Session 4: Foundational Microelectronics
Microelectronics Innovation in the Beyond Moore Era

Dave Robertson
Analog Devices
Five “Seismic Shift” Research Priorities: Unsustainable Exponentials . . .

- The Analog Data Deluge
- The Growth of Memory and Storage Demands
- Communication Capacity vs. Data Generation
- ICT Security Challenges
- Compute Energy vs. Global Energy Production

By design, the Decadal Plan focuses on **WHAT to accomplish**, not HOW to accomplish it.

**Now, onto the roadmap . . .**
We are not alone . . . MAPT Roadmap in the context of related roadmaps & road-mapping activities
Who’s Driving?

Technology Push…

…Market Pull

and the importance of SCALE . . .
Technology Advance: Overlapping S-curve model . . .

Fig. 1. Life cycle curves of technology

Source: Own study based on 1.
Early Majority = Pragmatists
Laggards = Resisters
Early Adopters = Visionaries
Innovators = Technology Enthusiasts
Late Majority = Followers
Legacy = Resisters

Same Principles: Integrate the S-curve and you get the Technology Adoption Curve

Technology Adoption Curve/Life Cycle

Rate of Adoption

Time
IC Technology Stack

...tic-toc advances (climb the stairs)
...DTCO—design technology co-optimization STCO—system...
Co-Design and Complexity Management

• Enabling Electro-Thermo-Mechanical Analysis of a 2.5D or 3DIC system

• Co-Design of multiple dimensions
• Netlist, Pin Locations and Assembly
  • CSV or Verilog
  • 3Dblox or 3Dstack+ syntax
• 3Dstack and die-to-die connectivity
  • Virtual die extraction with xACT
  • Propose die-to-die PERC verification
• Power Analysis
  • Power models
• Thermal stress analysis
  • Thermal maps
• Comprehensive system simulation
Chapter 10: Digital Processing (and memory)

Energy, Energy, Energy . . . moving data

Het Integration

Co-Design

“New Curves”: Paradigms
Architectures
Devices

Processing Paradigms and Architectures (10.1, 10.2)
- Conventional
- Data Centric
- Data-driven
- Neuromorphic
- Quantum Annealing
- General-Purpose Quantum Computing

Device, Interconnect, Materials and Process (10.3)
- CMOS Device Architecture
- Device Innovations
- Memory Devices and Innovations
- Interconnections: 2D and 3D and Interposers
- Materials
- Process/Manufacturing

Applications
- HPC
- Mobile applications
- Intelligence on demand
- Big data processing
- IoTs and Edge, Continuum Computing
- Blockchain processing
- Others

Figure 10.1. Overall theme of this chapter

Chiplet Technologies
- Logic
- Memory
- Integrated Memory and Logic
- Analog Memory and Accelerators
- Interconnections

Ubiquitous Connectivity and Computing: Edge/IoT, Cloud and Hybrid
- Sustainability and Energy Constraints

SRC
Chapter 11: Analog/Mixed Signal—

• Mixed Signal Processing: coping with the deluge
  • Partitioning: Edge processing, including analog pre-processing
  • Critical roles for data converters, bit transport (PHY), and clocks
  • Special needs: EDA, package, process . . .

• Power Technology: pushed by the extremes:
  • Mega/giga-watt: high power (EV to grid) pushing wide bandgap
  • Nano-watt: Nano-power technologies and architectures
  • It’s not just getting the power in . . . It’s getting the heat out . . .
  • Battery evolution— a significant center of innovation

• RF/mmWave Technology: more bandwidth, higher frequencies, lower power
  • Applications— more than just cellular and radar . . .
  • Diverse technologies— the right tools for the job
Chapter 12: Sensors/Actuators Key Points

• Exceptional Diversity: (hard to make a common platform)
  • In materials/fabrication
  • In Integration: package challenges, radically different Heterogenous Integration technologies
  • Unique test requirements

• The sensor “explosion” – runaway exponentials?
  • Data Deluge
  • Sustainability: materials sourcing, recycling, energy . . .
  • Security: very different attack surfaces

• Photonics/Optical – beyond long haul data
  • Bandwidth, density, reach and power . . .
  • Solid state integration enabling penetration of shorter reach
  • More and more optical/photonic sensing modalities and applications

• AI and Sensors – Opportunities (and Challenges)
  • Opportunity to tackle the complexity of calibration, classification, recognition, fusion
  • Challenge is to safely, securely, and responsibly use AI to process and fuse sensor data to create actionable intelligence.
Session 4 Panel Discussion

Session Chair: Kanad Ghose, Distinguished Professor, Binghamton U

*Energy-aware systems and microarchitectures, hardware security*

- David Robertson, Technical Fellow, Analog Devices
  - *Mixed signal circuit design and communications systems*

- Tayseer Mahdi, Research Engineer, Intel
  - *Synthetic chemistry, new materials development for patterning using EUV Lithography and Directed Self Assembly*

- Michael Spencer Professor, Interim Chair Dept of Electrical and Computer Engineering, Morgan State
  - *Wide bandgap materials and power devices*

- Mary Ann Maher, CEO, Softmems
  - *MEMs, Sensors*

- Thomas LeBrun, Research Physicist, NIST
  - *Integrated photonics for PNT (positioning, navigation, timing), sensing, and quantum information*

- Min Tsao, Director of Engineering, Siemens EDA
  - *Computer Engineering, design rule checking and computation lithography software on advanced computing platforms*