ARTIST Summer School in Europe 2010

Autrans (near Grenoble), France

September 5-10, 2010

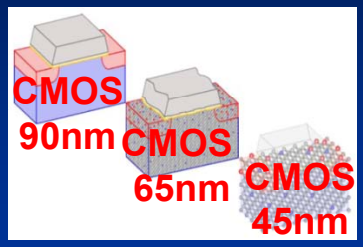
Thermal-Aware Design of 2D/3D Multi-Processor System-on-Chip Architectures

Invited Speaker: David Atienza,

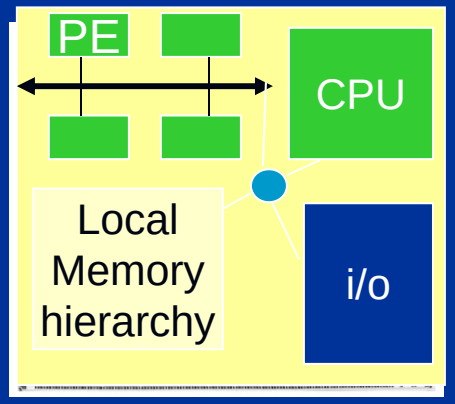
Professor and Director of Embedded Systems Laboratory (ESL), EPFL

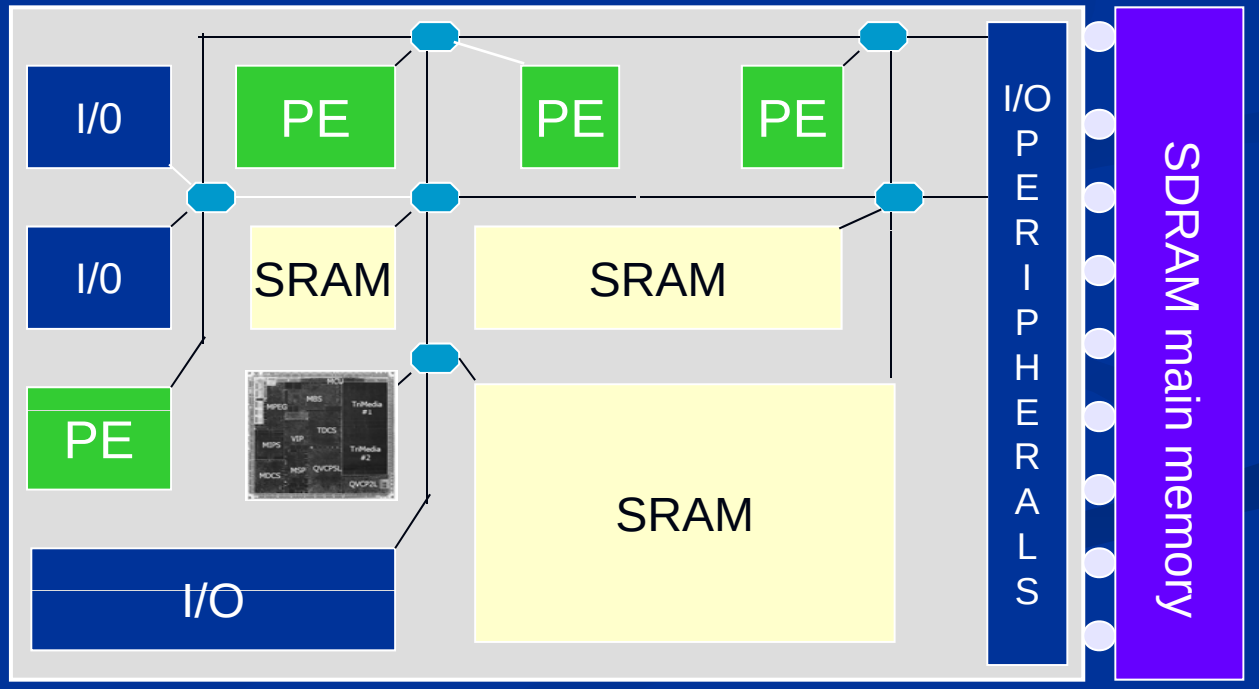
Evolution of Electronics to Multi-Processor System-on-Chip (MPSoC)

- Roadmap continues: 90→65→45 nm



- Multi-Processor System-on-Chip (MPSoC) architectures





Evolution of Electronics to Multi-Processor System-on-Chip (MPSoC)

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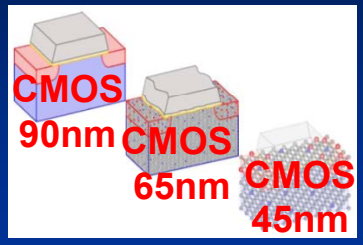
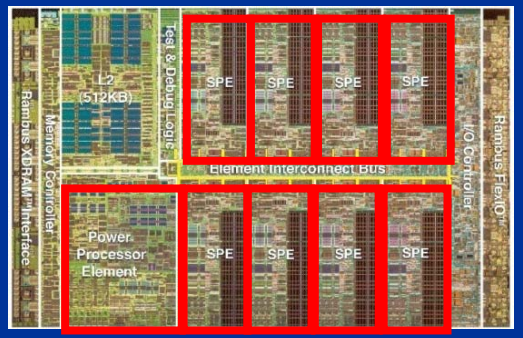
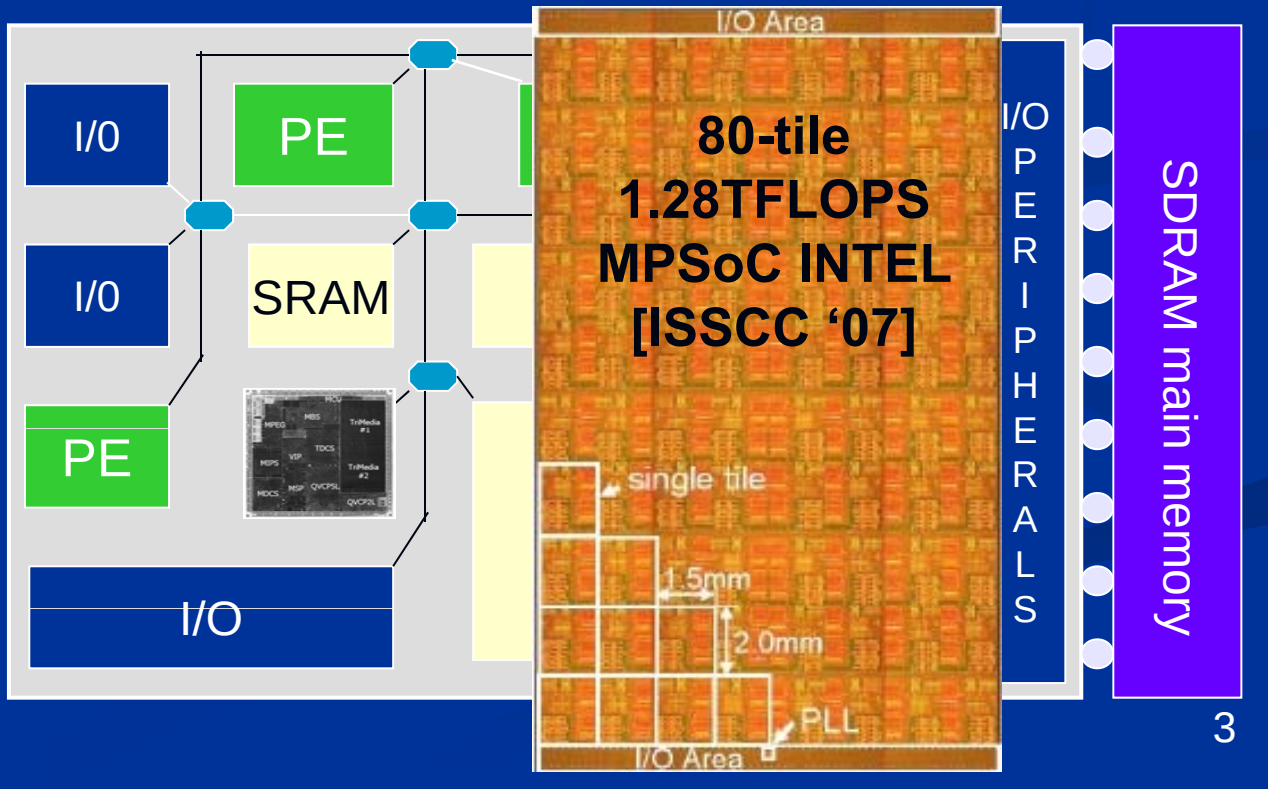


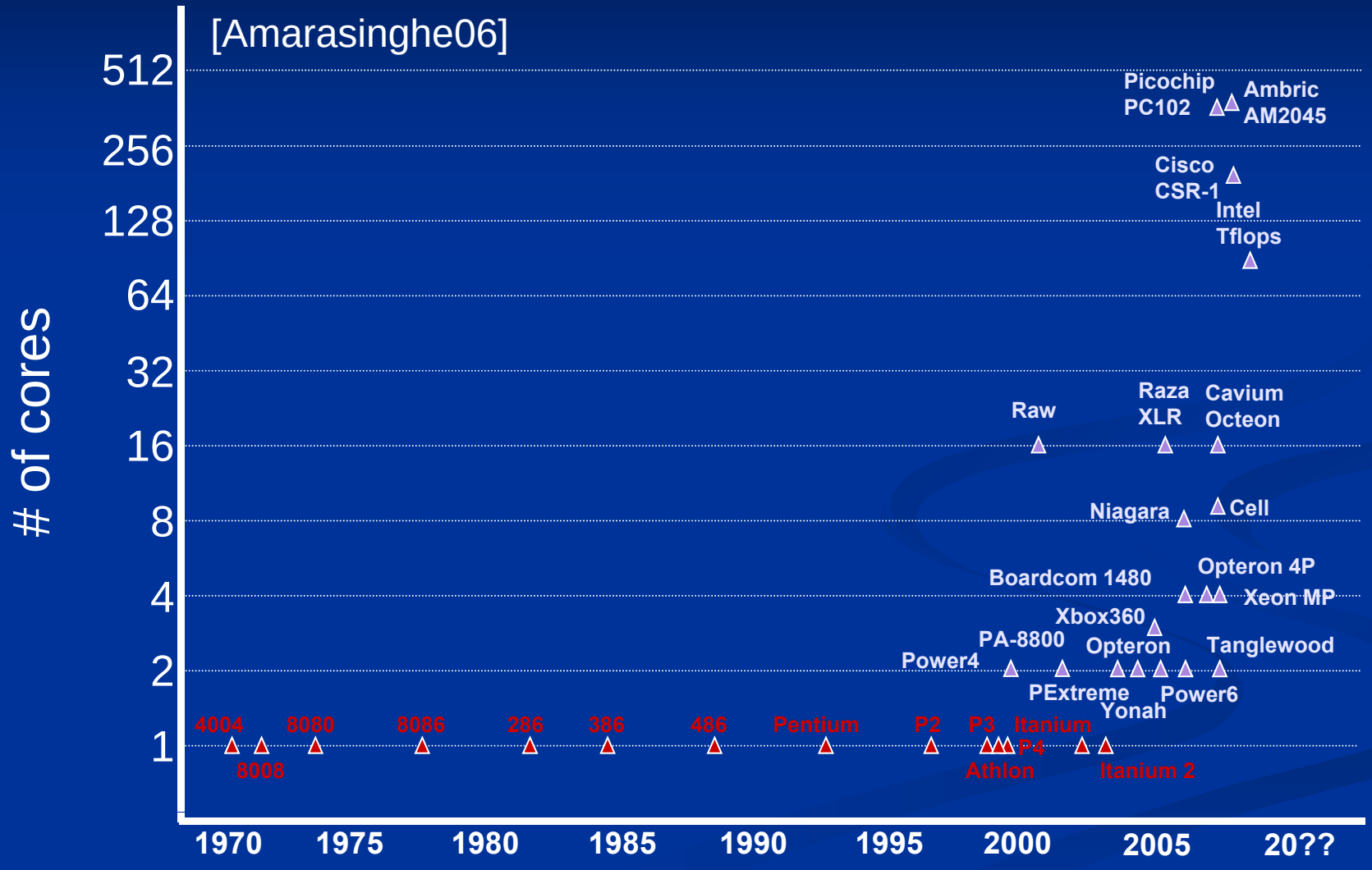
- Multi-Processor System-on-Chip (MPSoC) architectures



[Cell Multi-Processor – PS3]



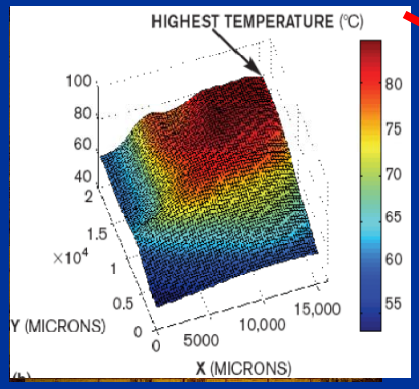
MPSoCs are Spreading Fast



Design Issues in MPSoCs

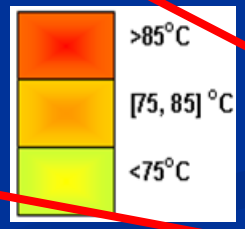
- MPSoCs have very complex architectures
  - Advanced components and CAD tools very expensive
  - Time-closure issues, system speed decreased
- Aggravated thermal issues
  - Hot-spots, non-uniform thermal gradients

[Sun, 1.8 GHz Sparc v9 Microproc]



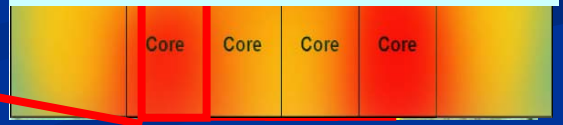
[Santarini, EDN, March '05]

[Sun, Niagara Broadband Processor]

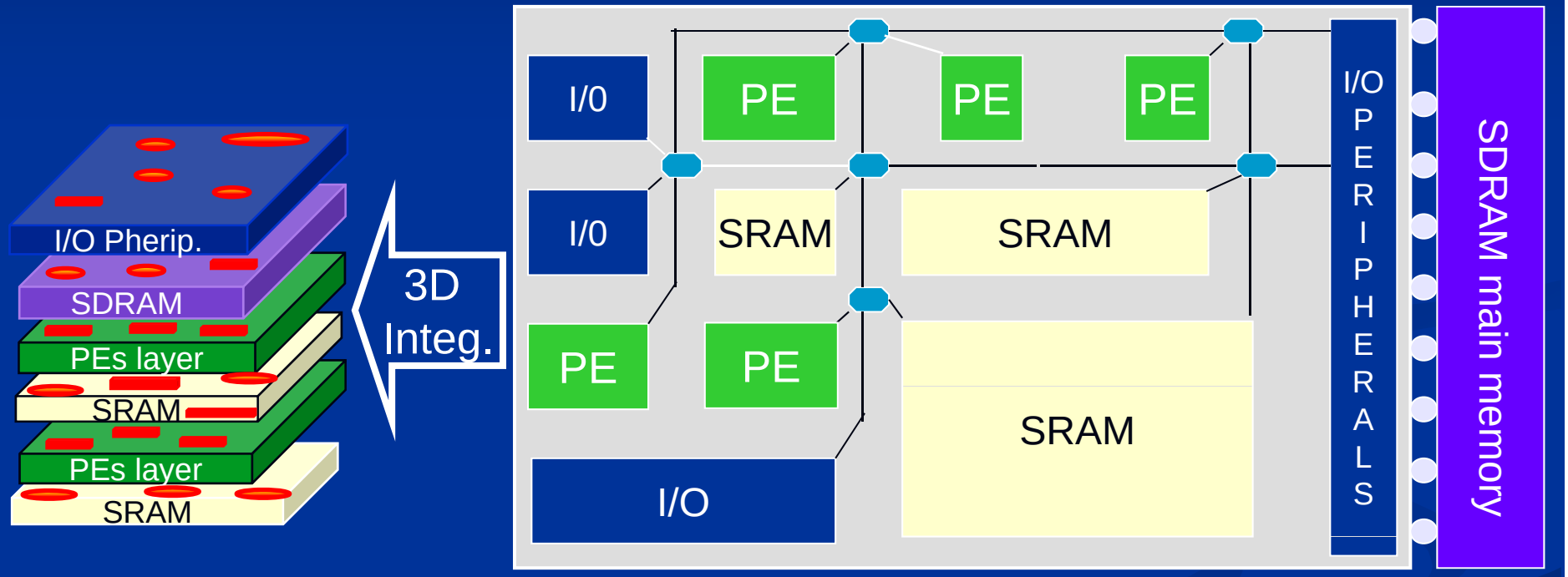


[Coskun et al '07, Sun]

High chances of thermal wear-outs and very short lifetimes!



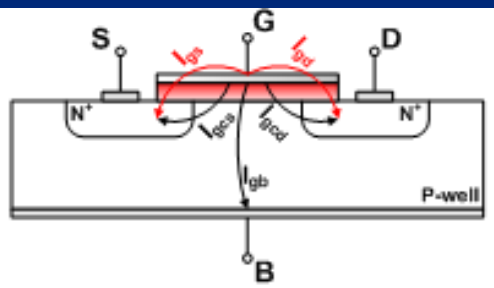
Thermal Issues Become More Critical for 3D-MPSoCs



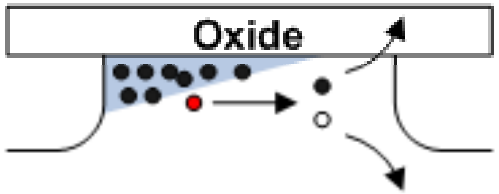
More power and more non-uniform heat spreading!

Reliability Degradation Factors in MPSoCs

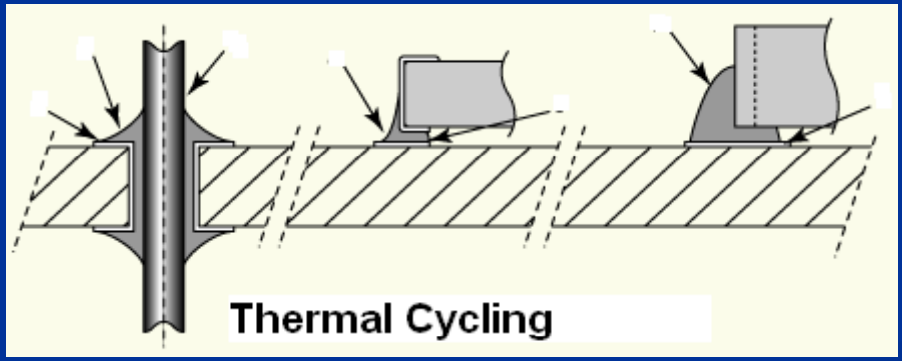
Electromigration (EM)



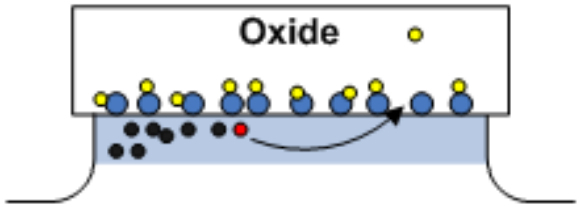
Oxide Breakdown



Hot carrier injection (HCI)



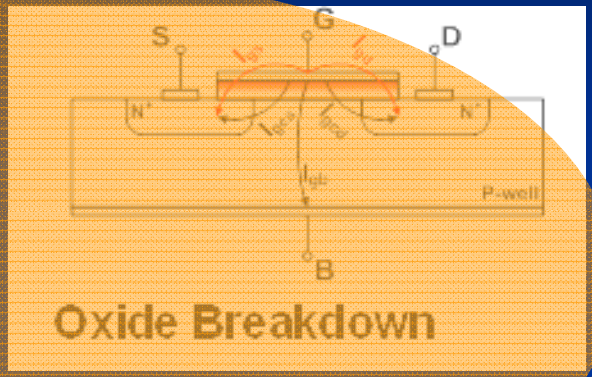
Thermal Cycling



Negative Bias Temperature Instability (NBTI)

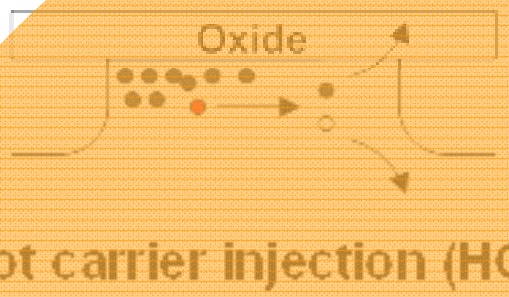
Reliability Degradation Factors in MPSoCs

Electromigration (EM)



Oxide Breakdown

Thermal Hot Spots



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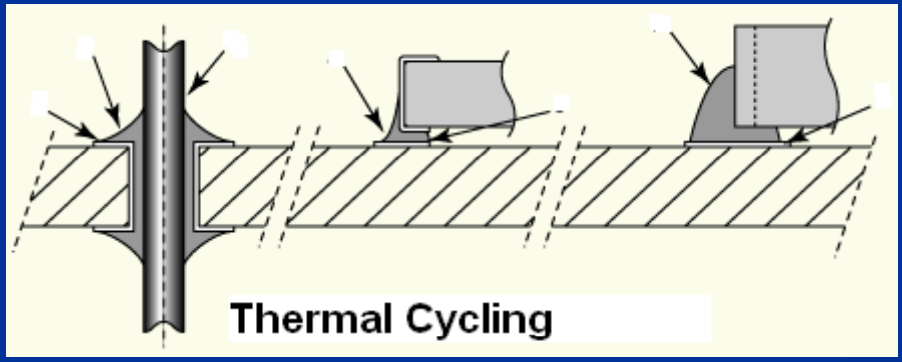

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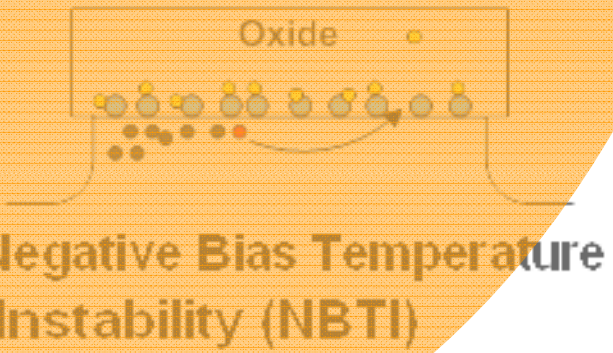

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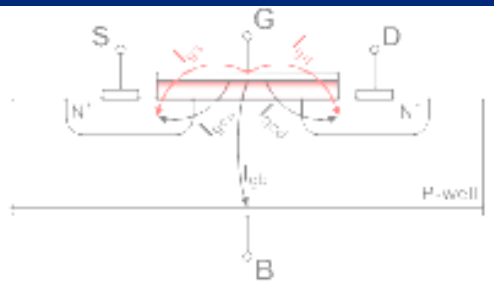

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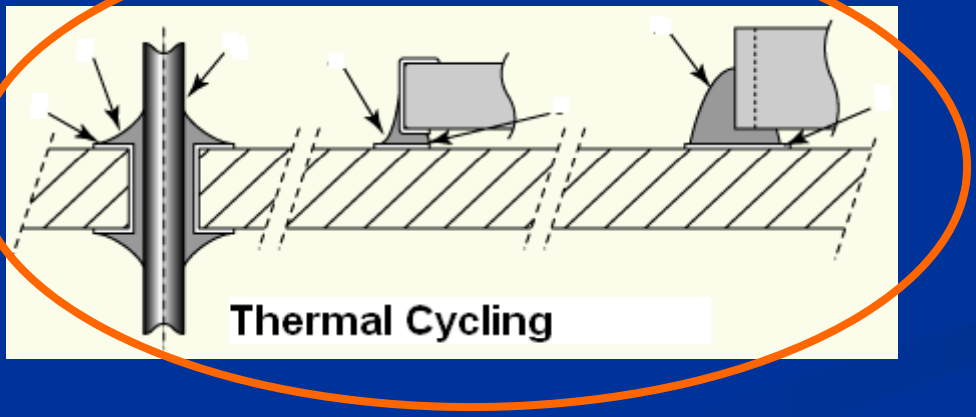

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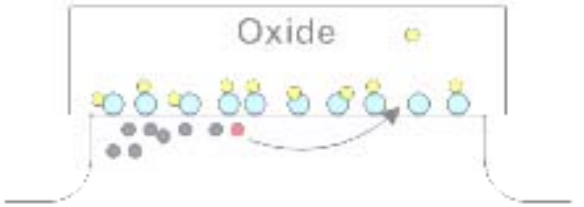
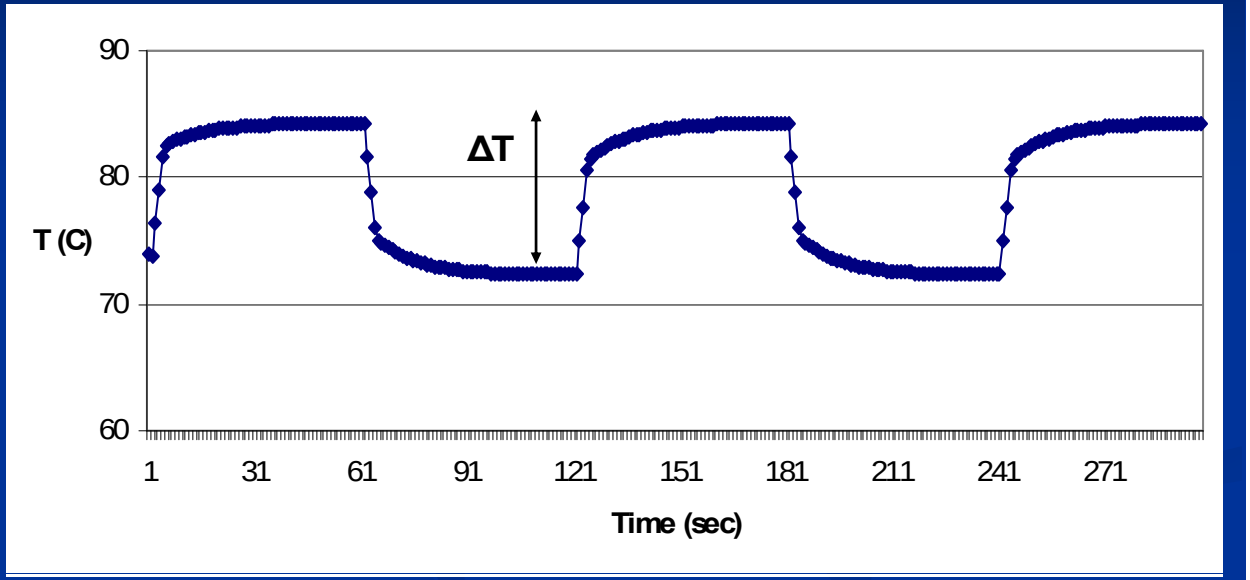
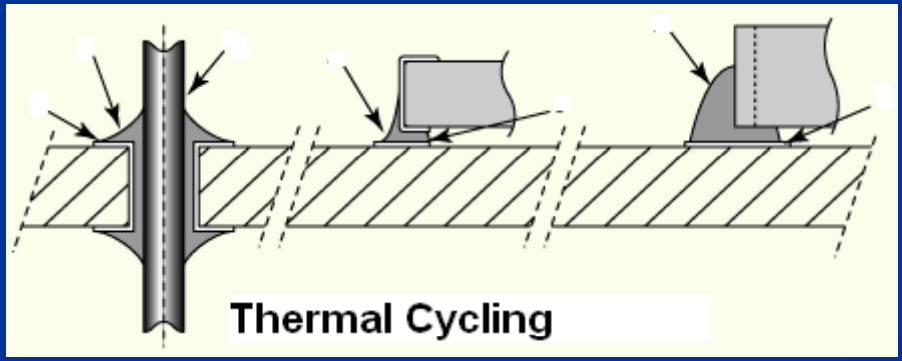


Negative Bias Temperature Instability (NBTI)

Reliability Degradation Factors in MPSoCs

- Fatigue failures increase with:
  - Magnitude of variation
  - Frequency of cycles

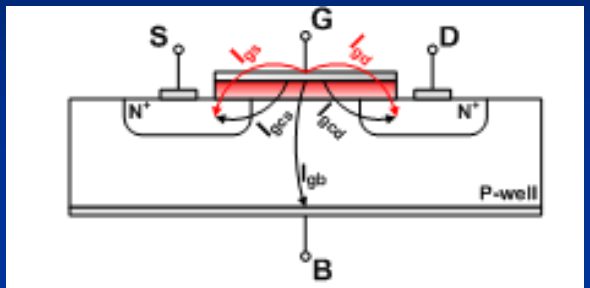




- Caused by:
  - Power on/ off
  - Power management (turning off cores)

Reliability Degradation Factors in MPSoCs

Electromigration (EM)



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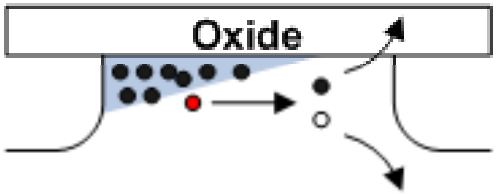

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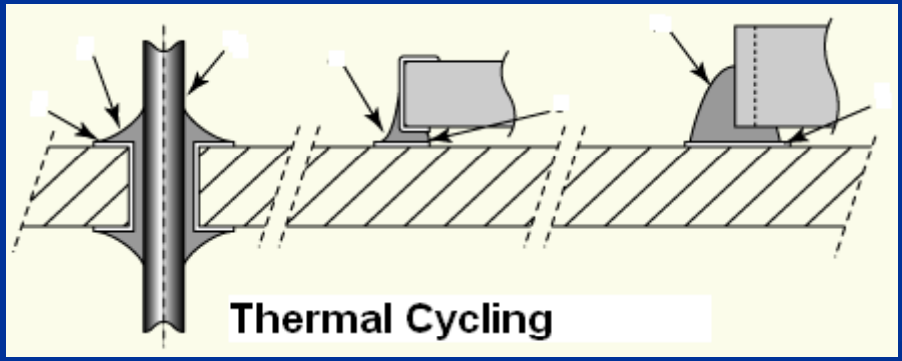

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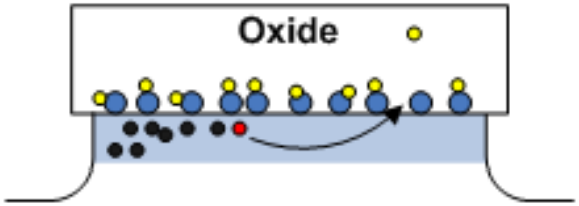

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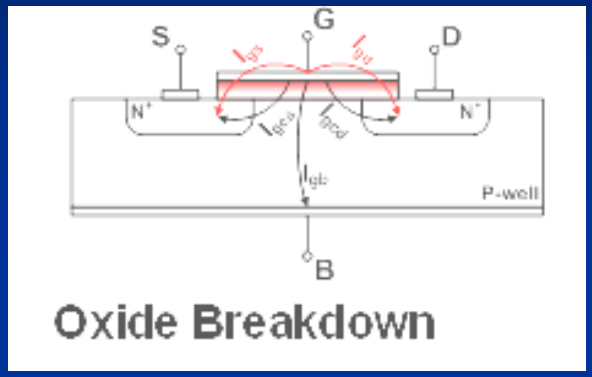
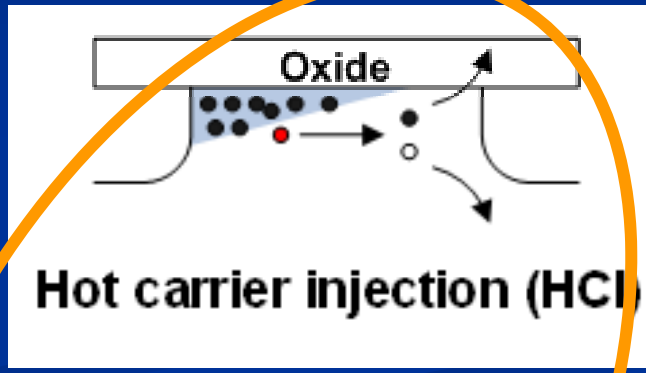


Oxide Breakdown

Spatial Gradients



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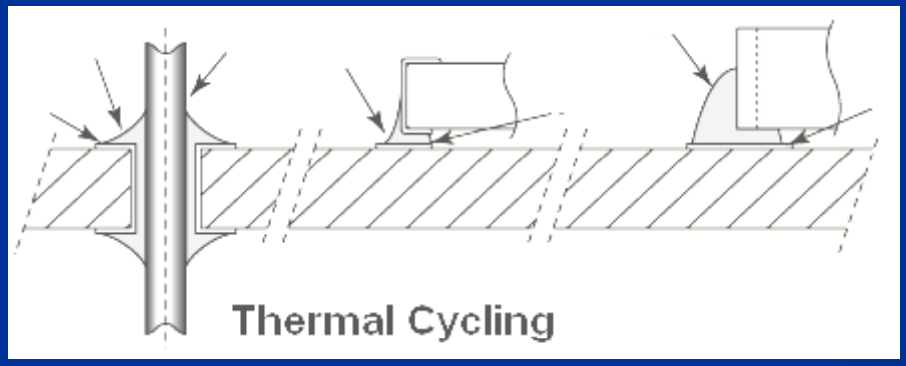

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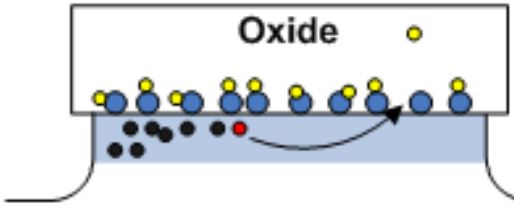
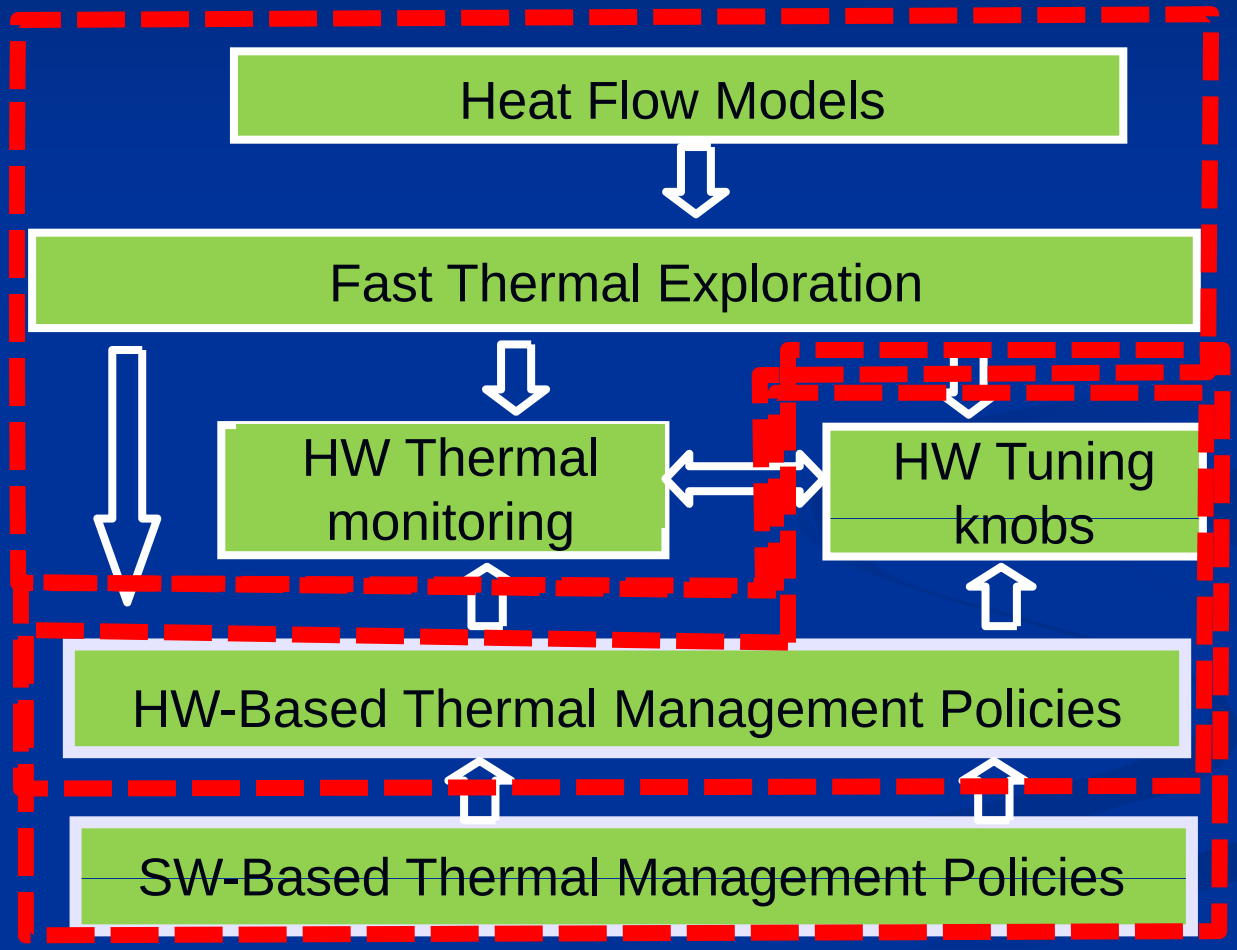


Negative Bias Temperature Instability (NBTI)

Advocating Thermal-Aware 2D/3D MPSoC Design

- Integration of HW/SW modeling and management



Outline

- Part 1: Thermal Modeling and Management for 2D MPSoCs
- Part 2: Thermal Modeling and Management for 3D MPSoCs with Active Cooling

Acknowledgements:

Prof. Ayse K. Coskun *(Boston University and Sun Microsyst.)*,
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