



PowerCool: Simulation of Integrated Microfluidic Power Generation in Many-Core Servers

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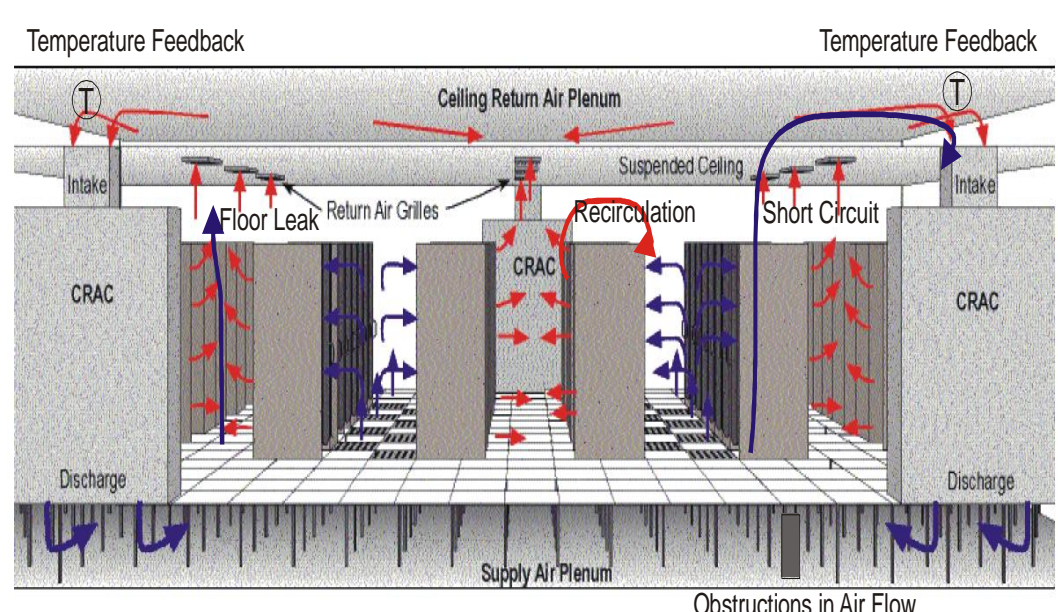
Motivation

High performance and high density computing servers demand high power supply: **cooling** and **power delivery** issues

Cooling issues

- High power density of ICs
- Energy efficiency constraints

Modern Air-Cooled Data Centers



Very high energy consumption overhead

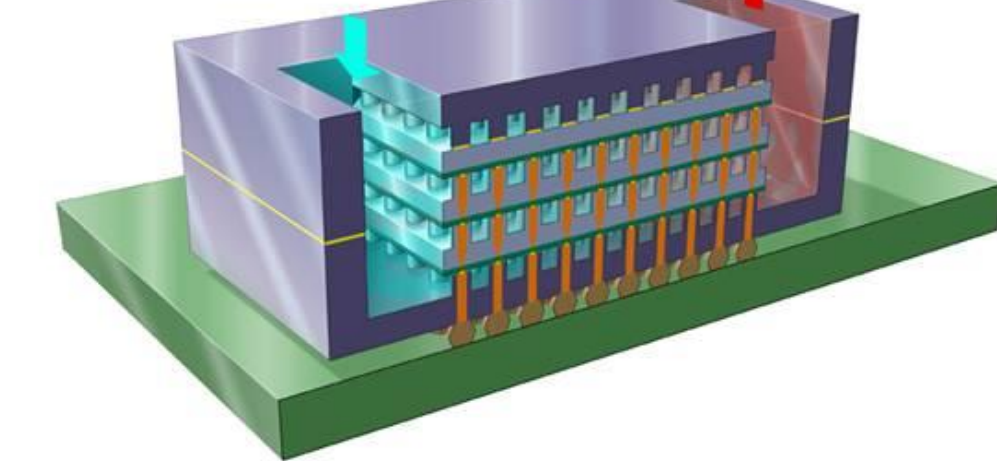


3D-ICE [1] Liquid cooled 3D stacked ICs simulator

Liquid-cooled ICs

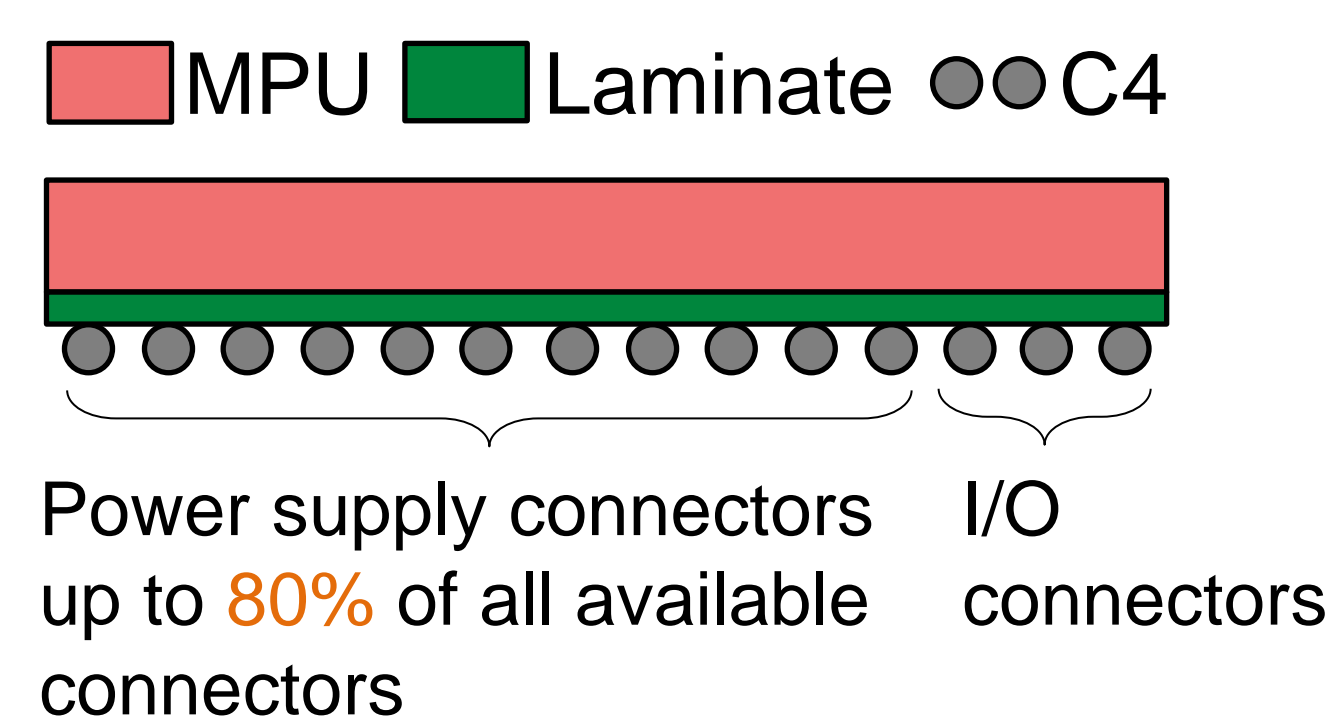
- High cooling capability
- Energy efficient
- 3D scalability

Future Liquid-Cooled Data Centers



Power delivery issues

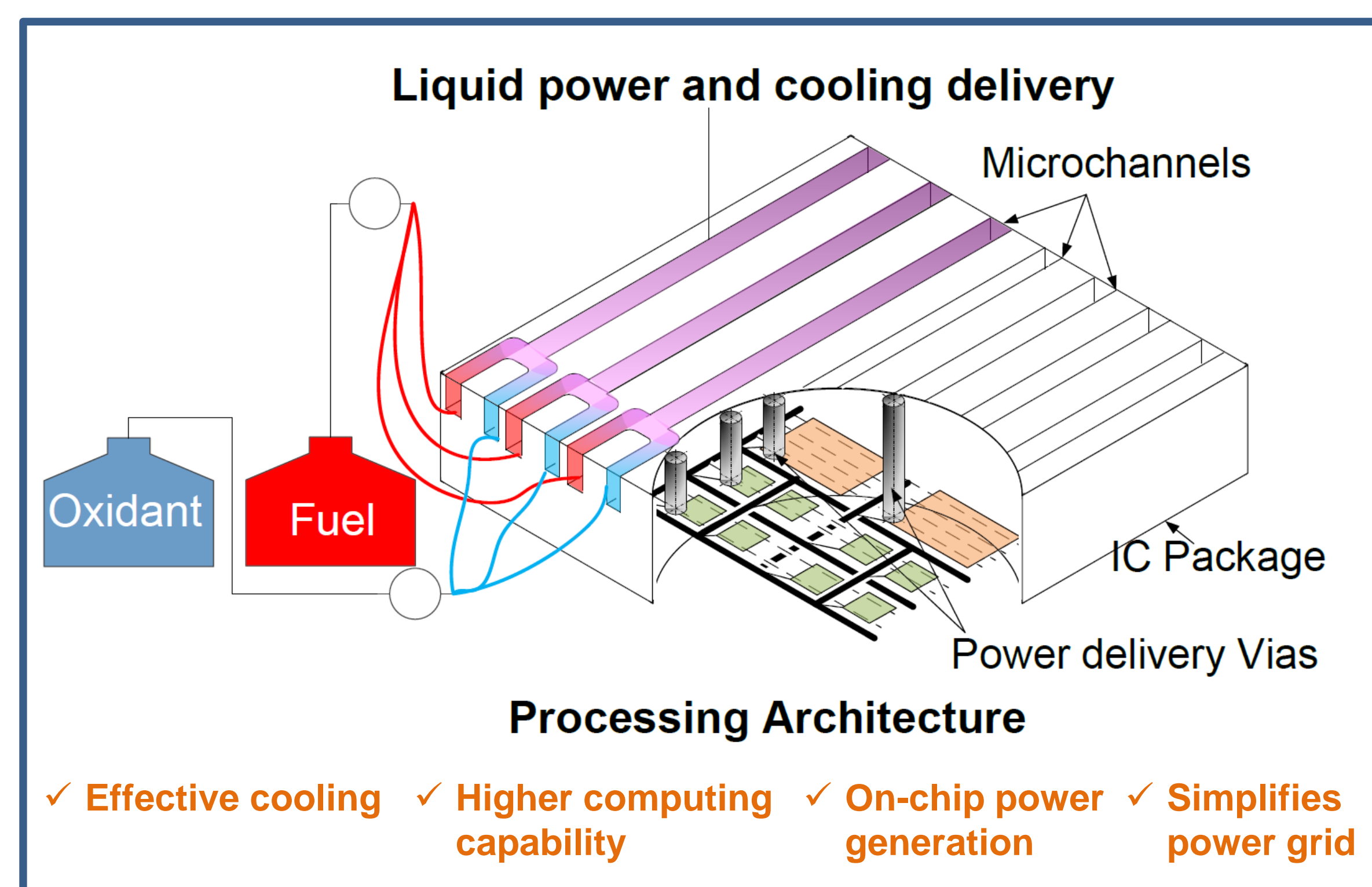
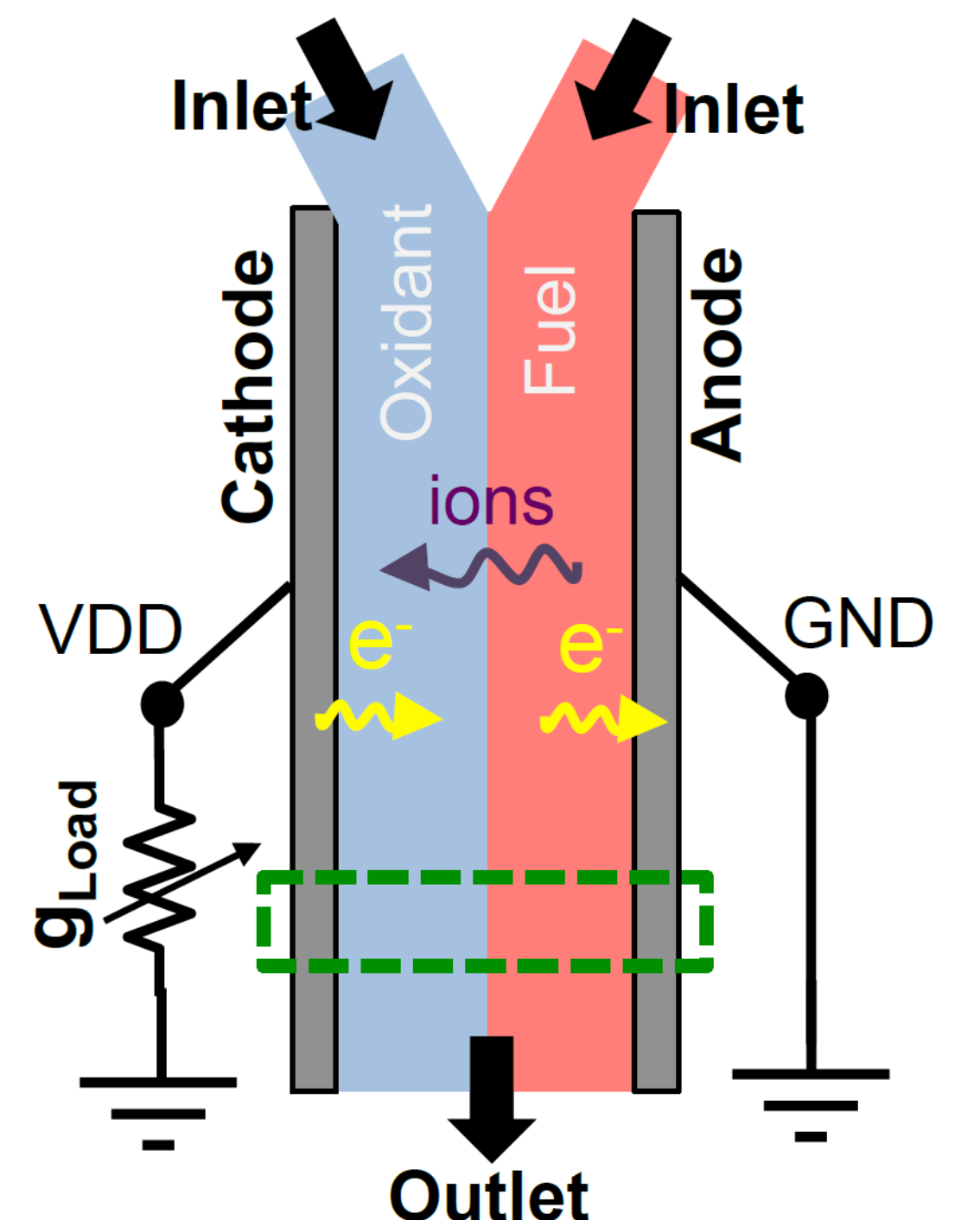
- Leakage losses
- Limited number of connection pins
- Complex power distribution network



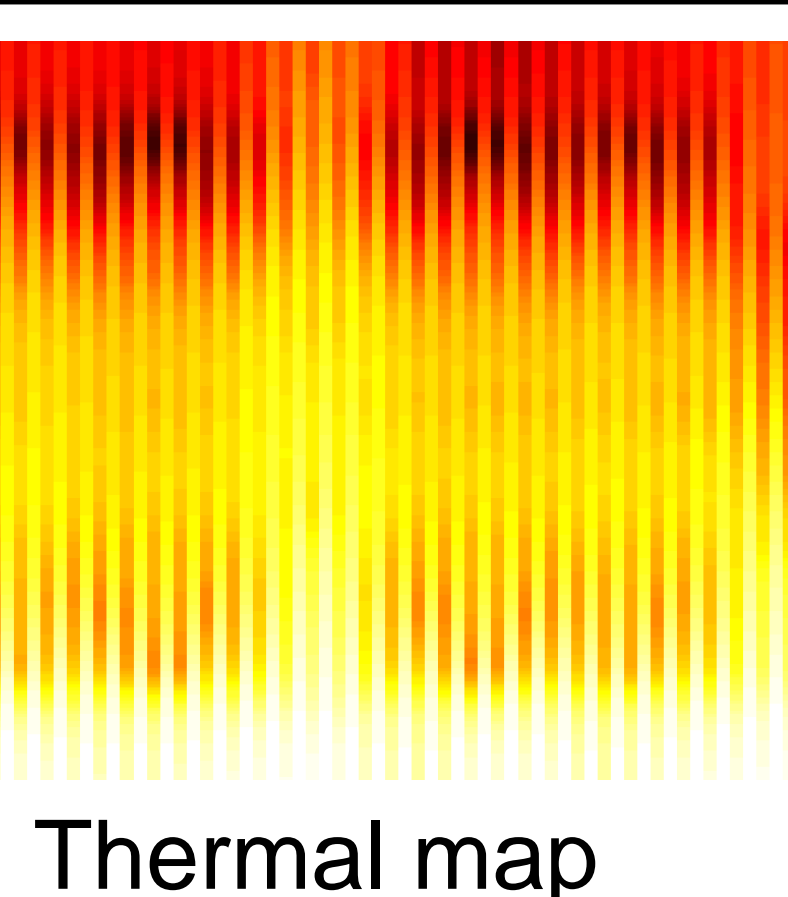
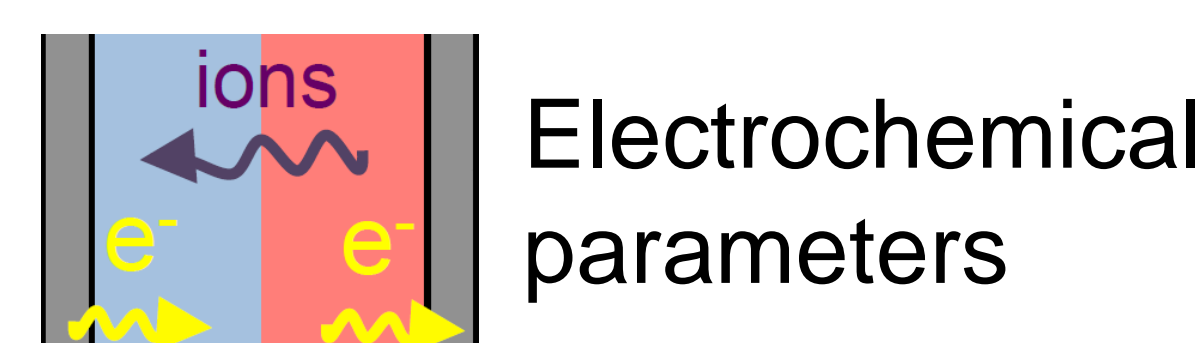
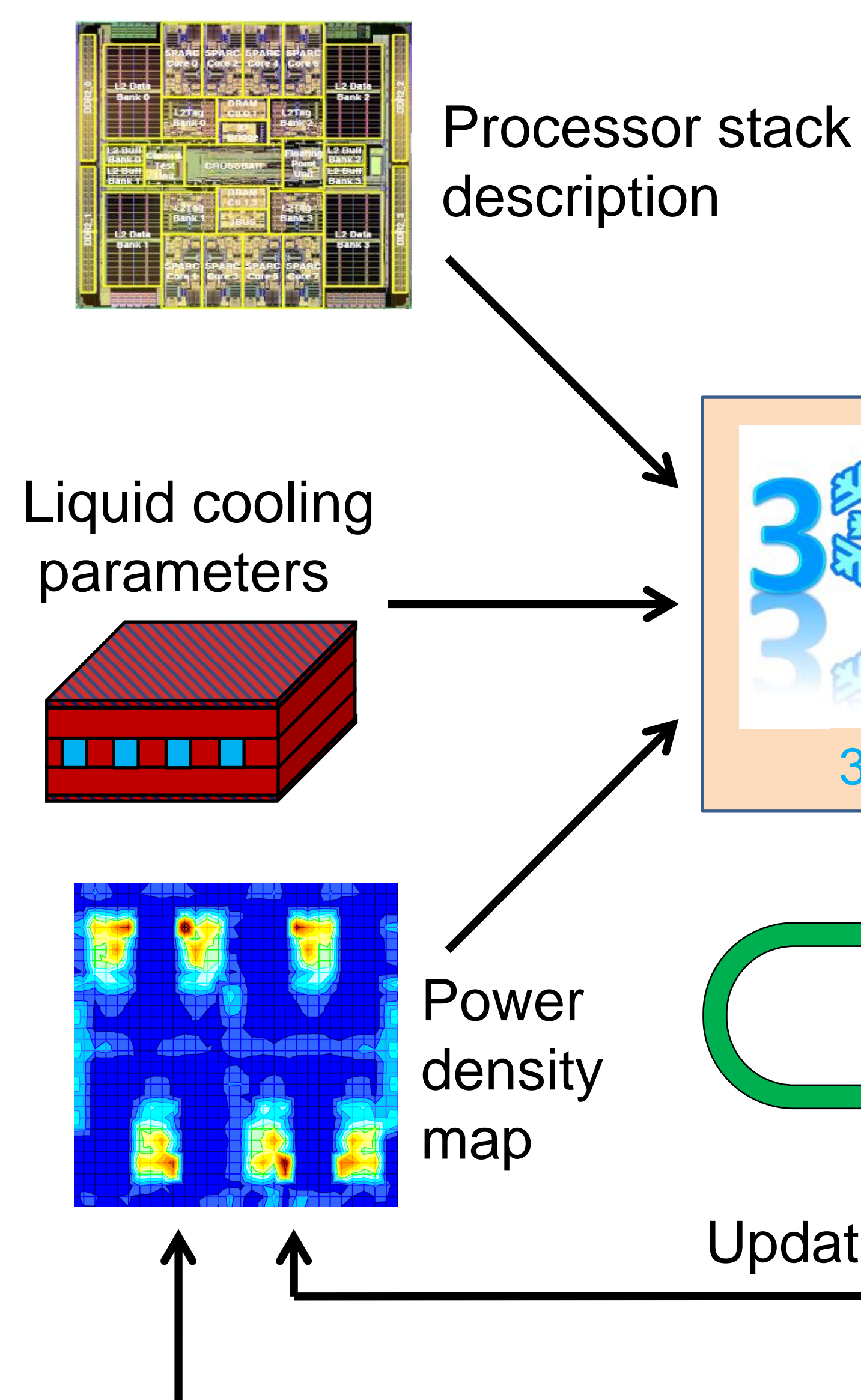
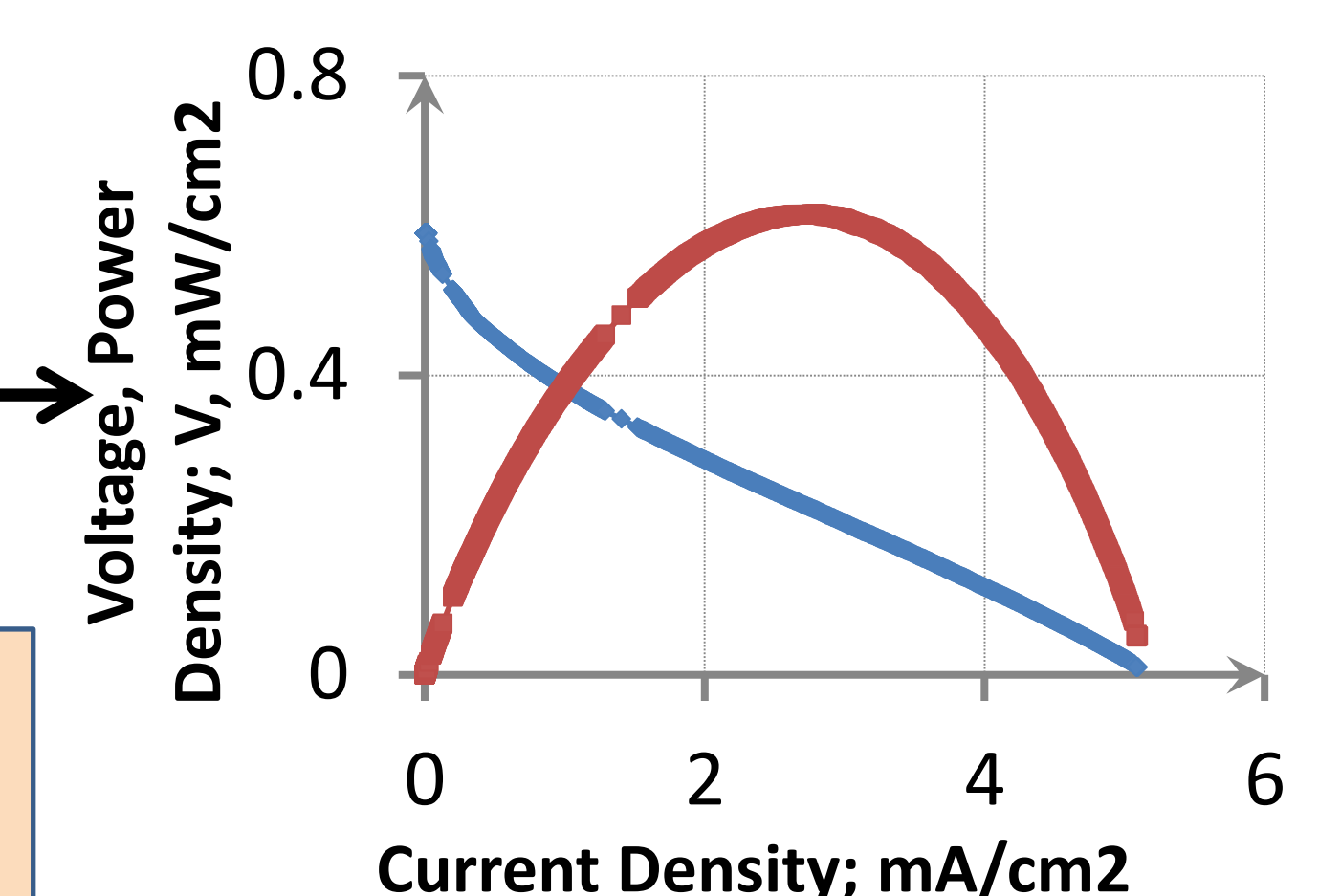
On-chip flow cell

- Significantly reduces losses
- Simplifies power distribution
- Saves pins for I/O
- 3D scalability

Electrochemical flow cell



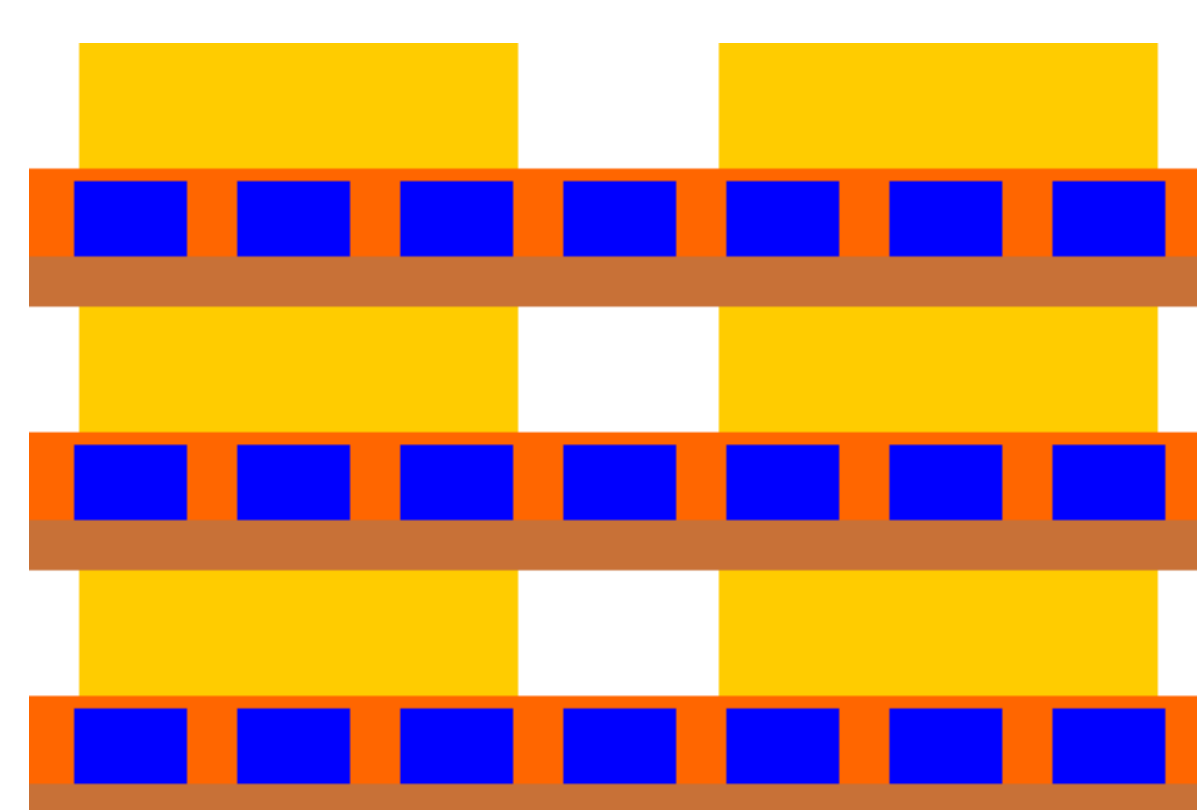
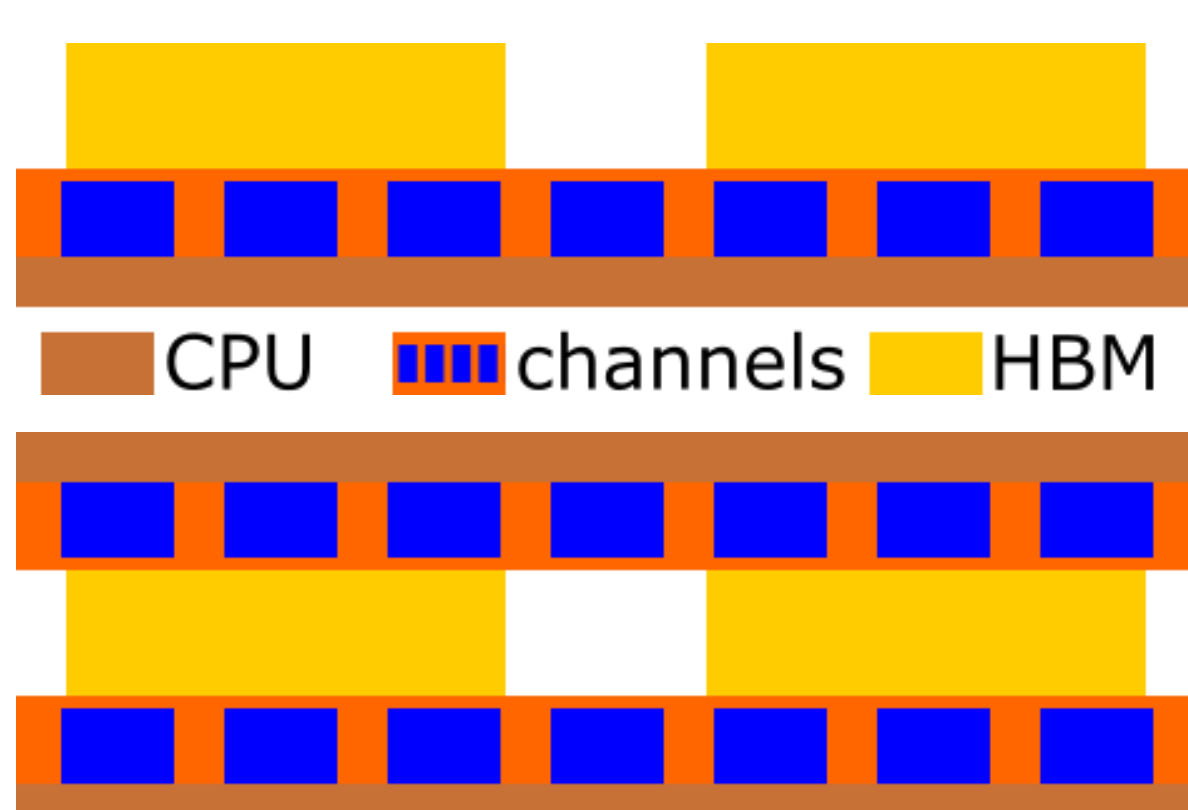
PowerCool [2] flow-cell array simulator



Flow-cell array power supply

Current state

- EDA-compatible tool
- Simulation of complex stacks
- FCA parametric dependence studies
- Trade-offs exploration



Future

- Flow cell technology exploration
- Channel shape optimization
- Floorplan-aware design
- Transient analysis

References

- [1] A. Sridhar, A. Vincenzi, D. Atienza Alonso and T. Brunschweiler. *3D-ICE: a Compact Thermal Model for Early-Stage Design of Liquid-Cooled ICs*, in IEEE Transactions on Computers, vol. 63, num. 10, p. 2576-2589, 2014.
- [2] A. Sridhar, M. M. Sabry, P. Ruch, D. Atienza Alonso and B. Michel. *PowerCool: Simulation of Integrated Microfluidic Power Generation in Bright Silicon MPSoCs*. Proc. of IEEE/ACM ICCAD 2014.