Proximity Communication and Time

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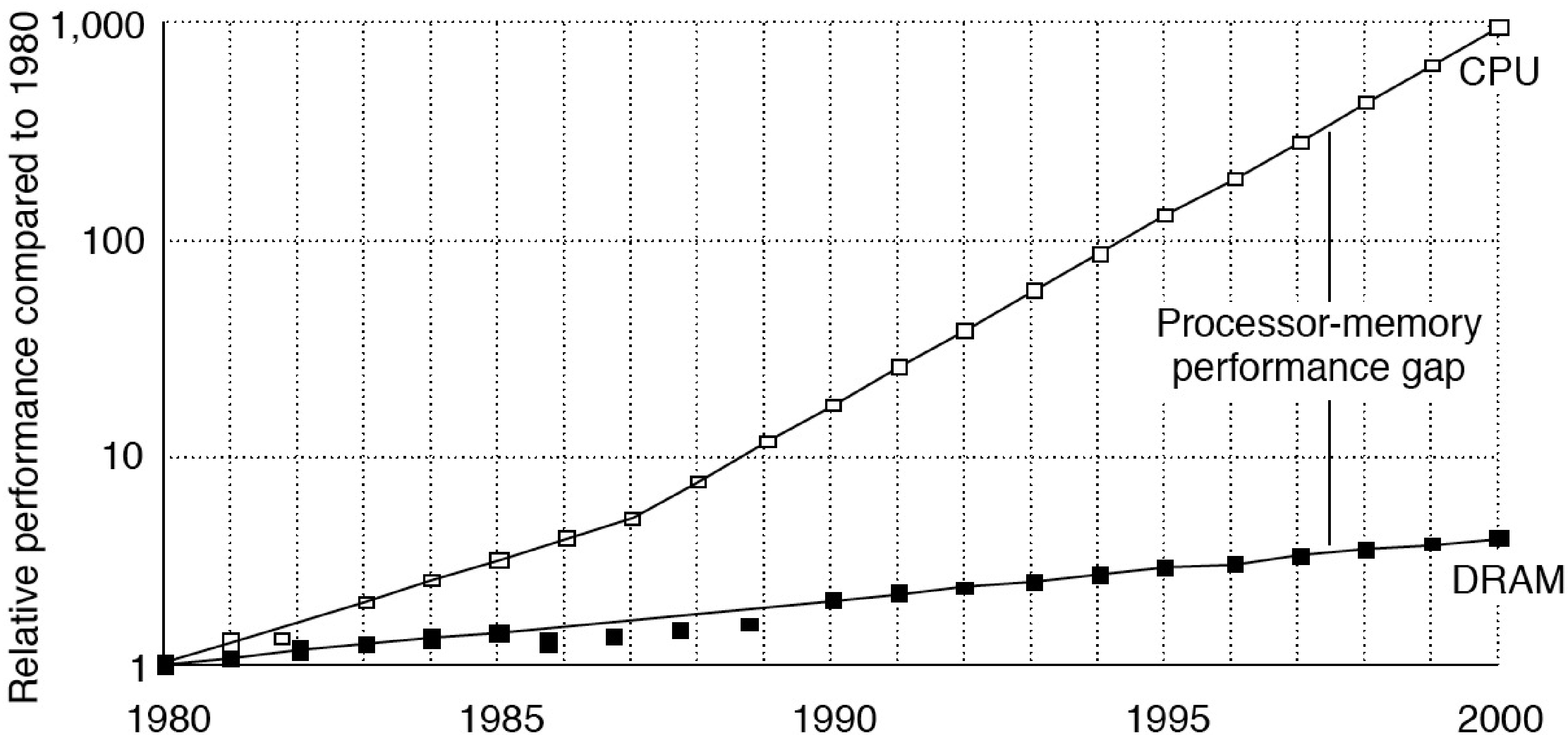
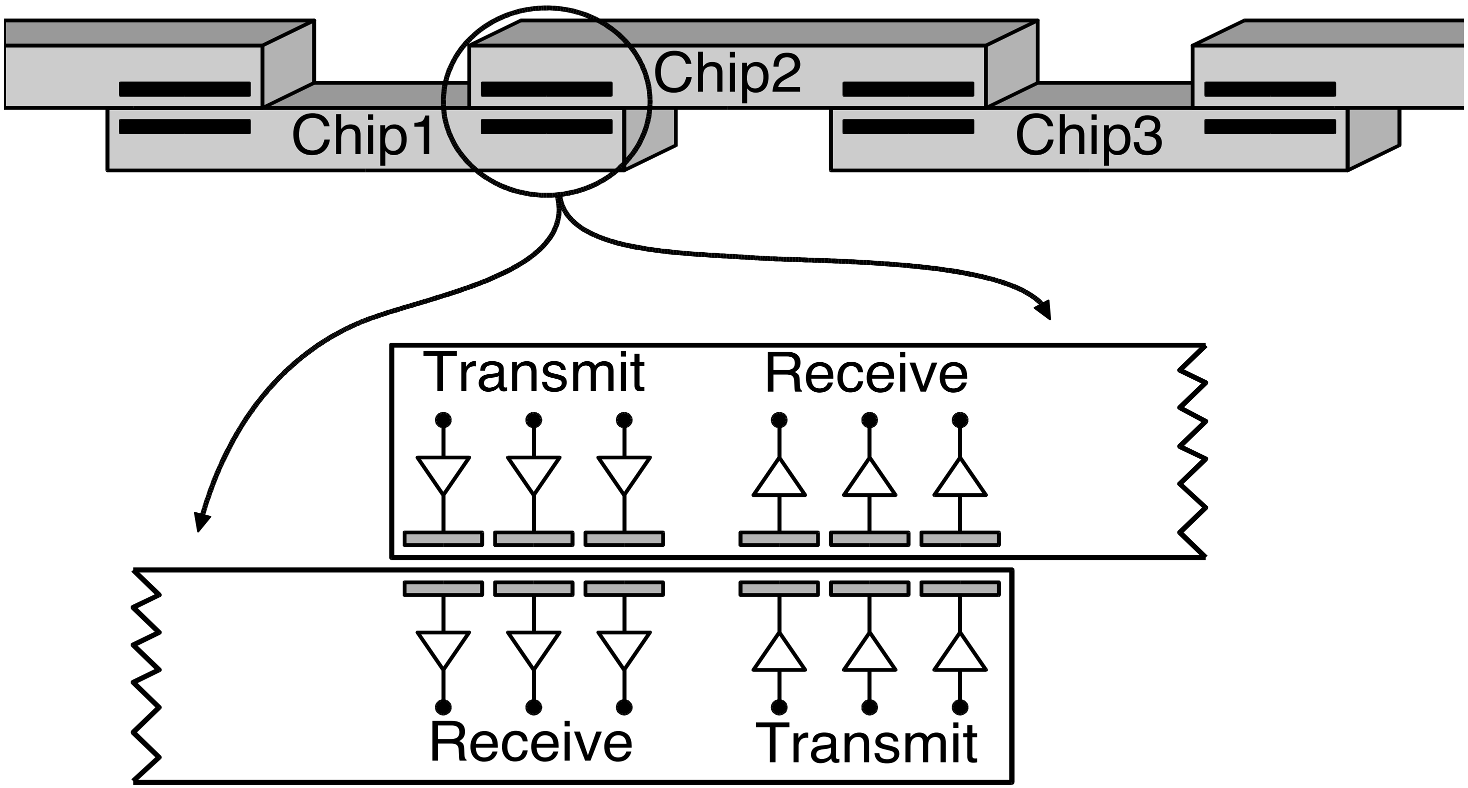
Motivation for Higher Bandwidth



J.L. Hennessy and D.A. Patterson, Computer Organization and Design, 2nd ed.

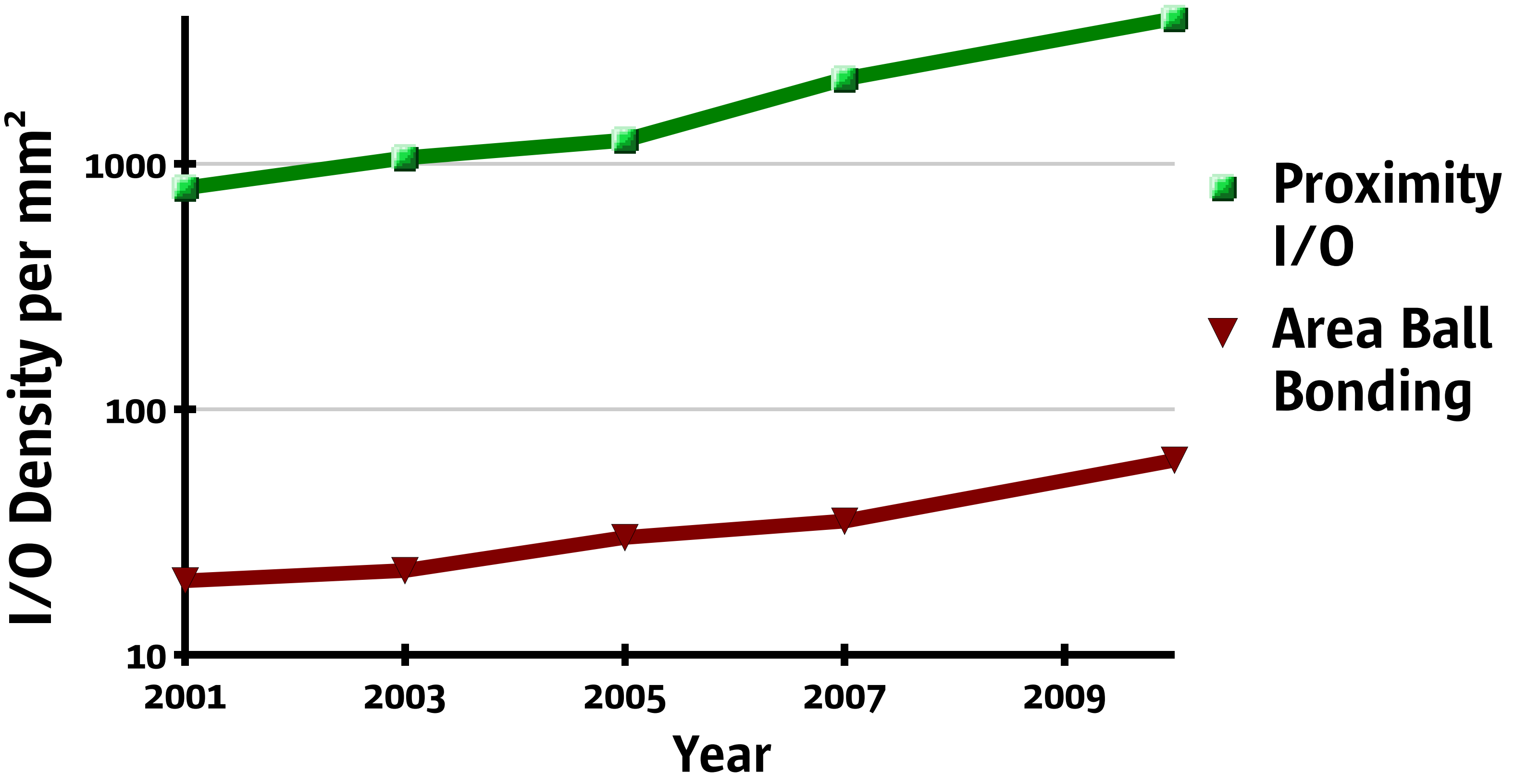
Proximity Communication



Proximity Communication Benefits

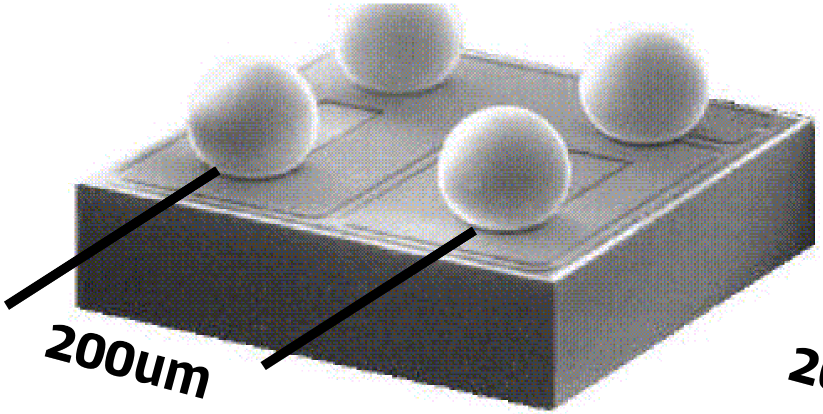
- Avoids Off-Chip Wires
- Increases Bandwidth/Area
- Makes Chips Replaceable......... ↑ System Yield
- Enhances Testing Capability...... ↑ System Yield
- Enables Smaller Chips............ ↑ Chip Yield
- Obviates ESD Protection........... Power ↓
- Shrinks Transmitter and Receiver.. Power ↓

I/O Density Comparison

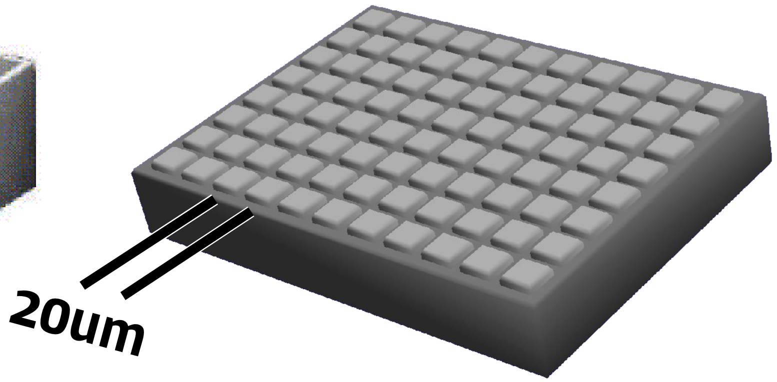


Comparison of Scale

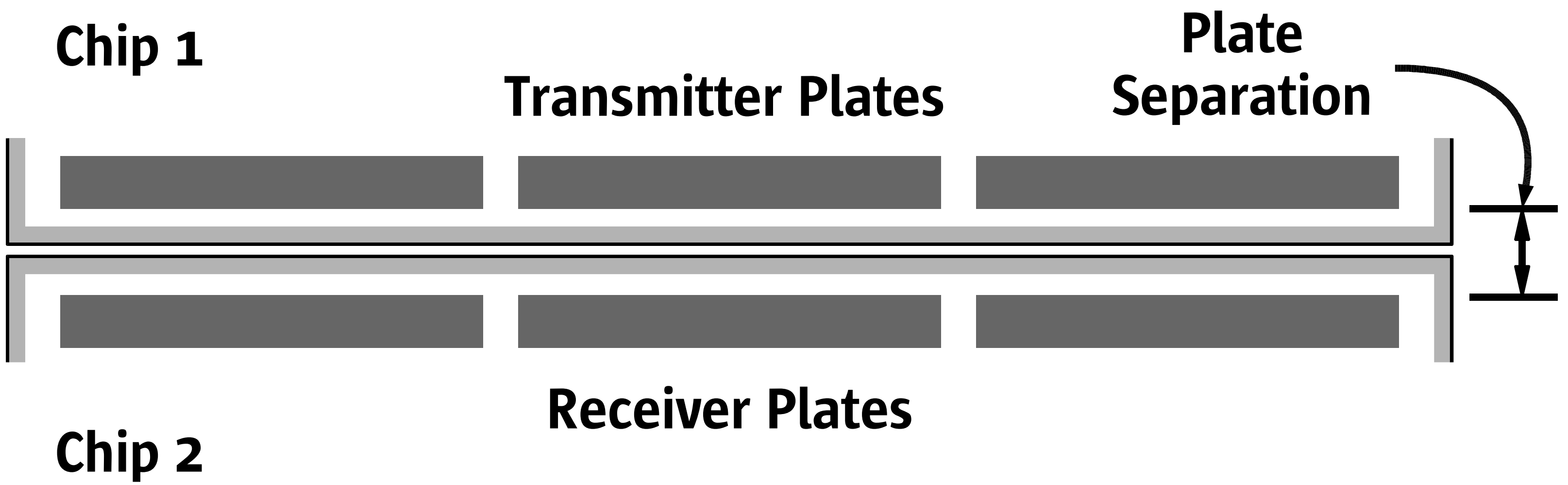
Area Ball Bonding



Proximity Communication



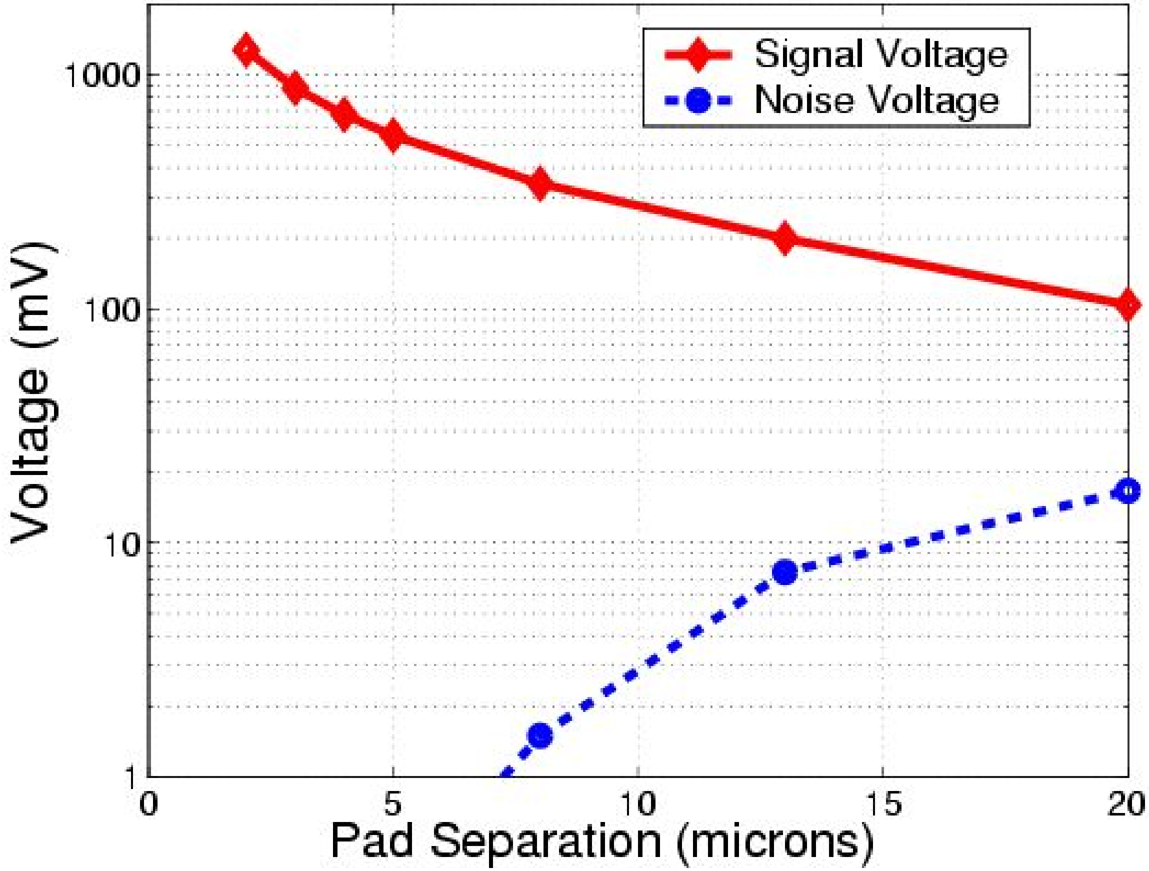
Pads Cross-Section



NOT to Scale!

Pads Cross-Section

Signal and Noise Simulated Coupling

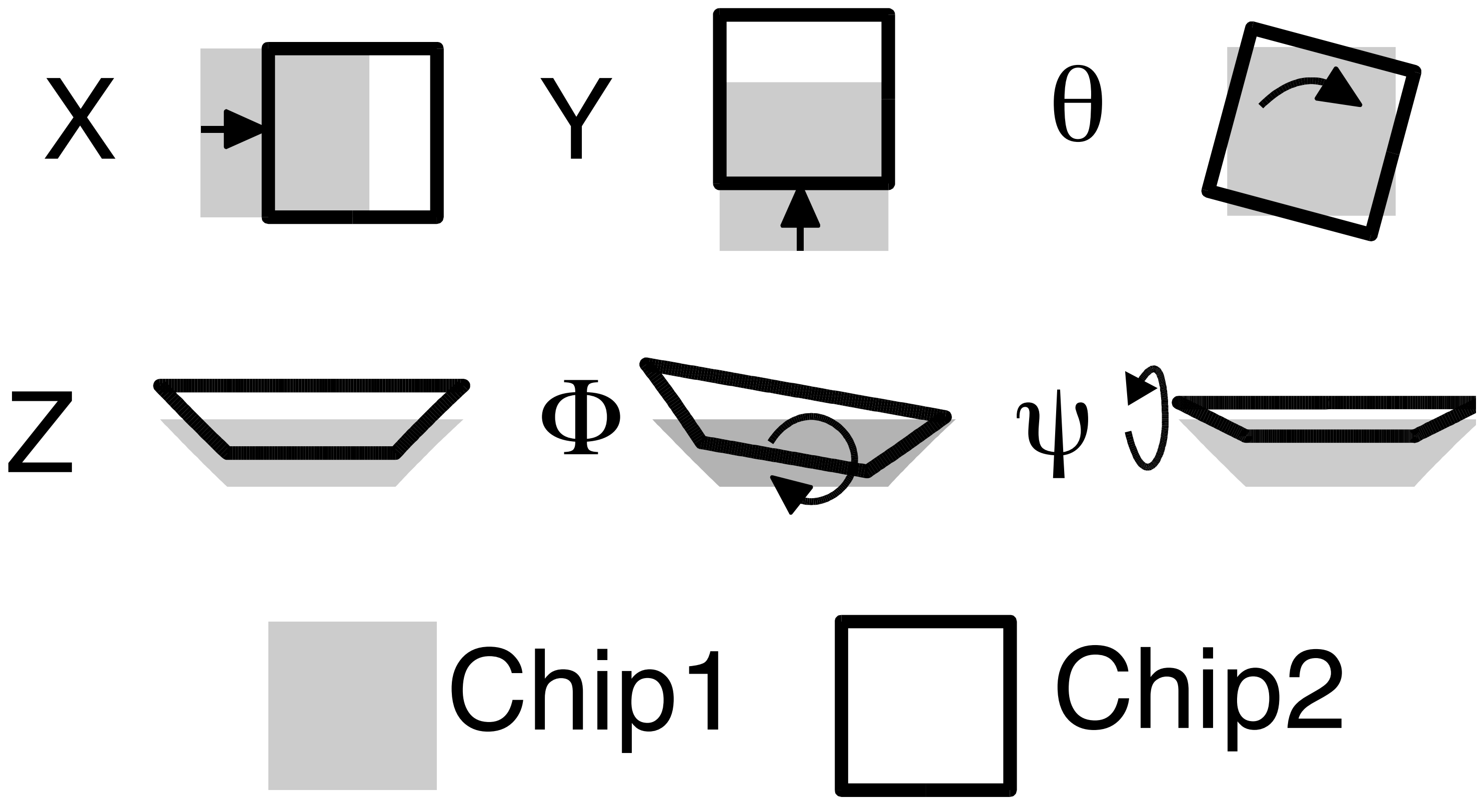


Mechanical Alignment Challenges

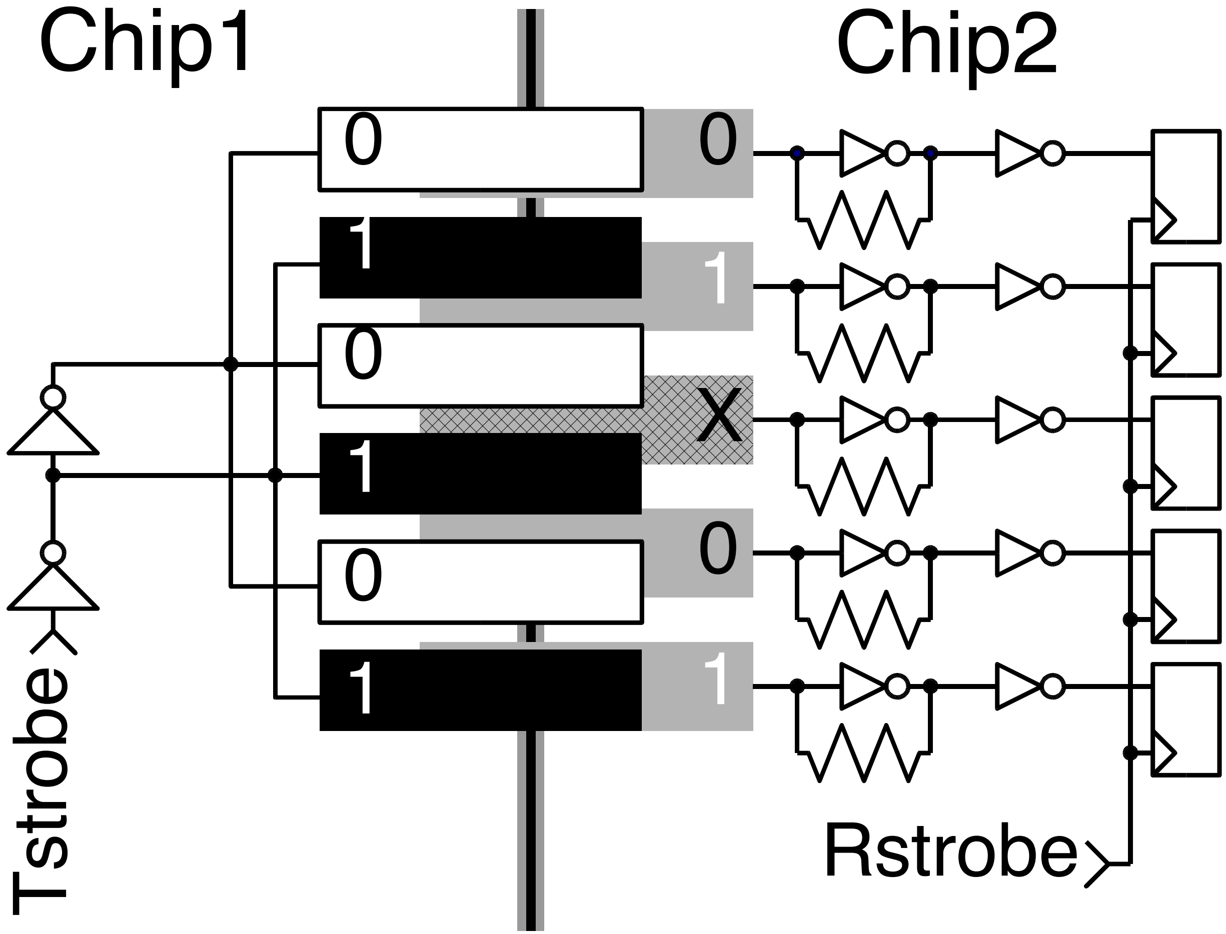
- Proximity Communication
  - Does not use permanent attach
  - Enhanced yield and utility, but is...

  sensitive to misalignment
  - Imperfect packaging
  - Thermal expansion causes misalignment
  - System vibration causes misalignment

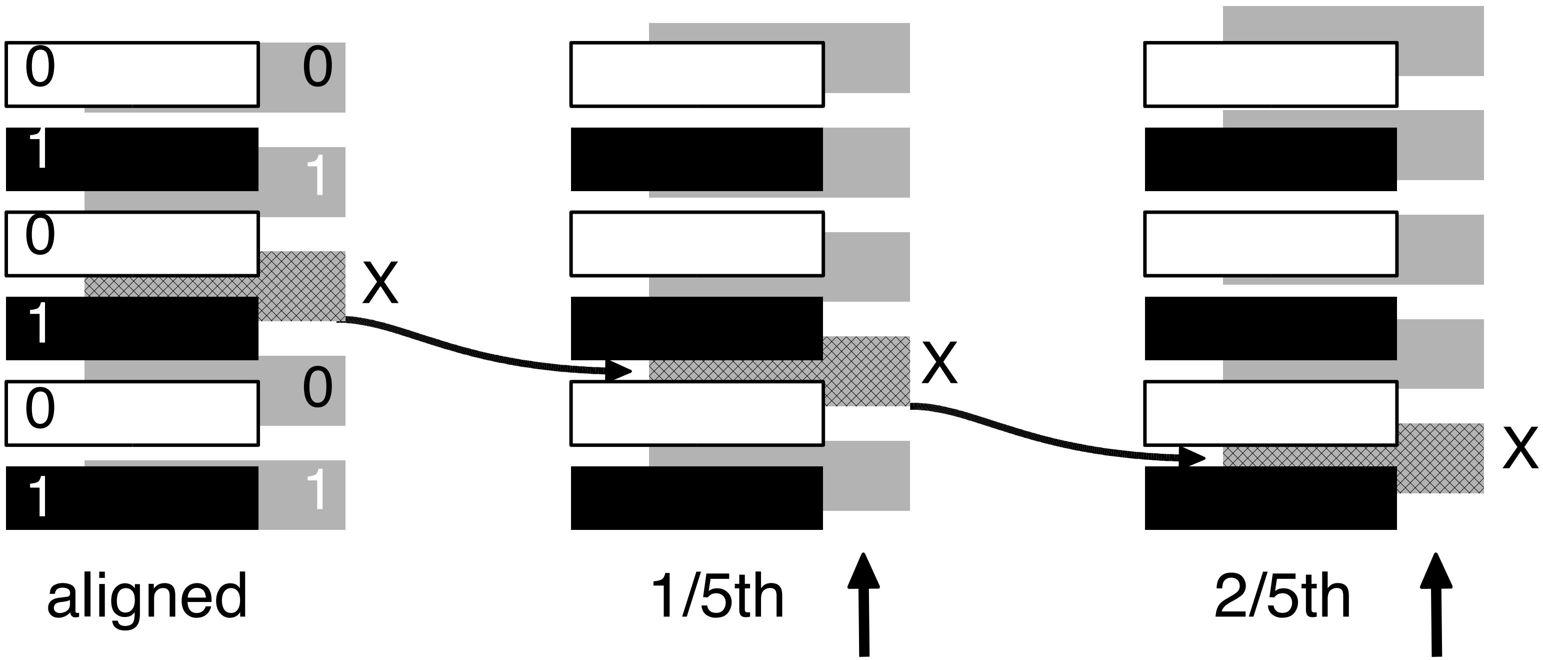
Six Degrees of Misalignment



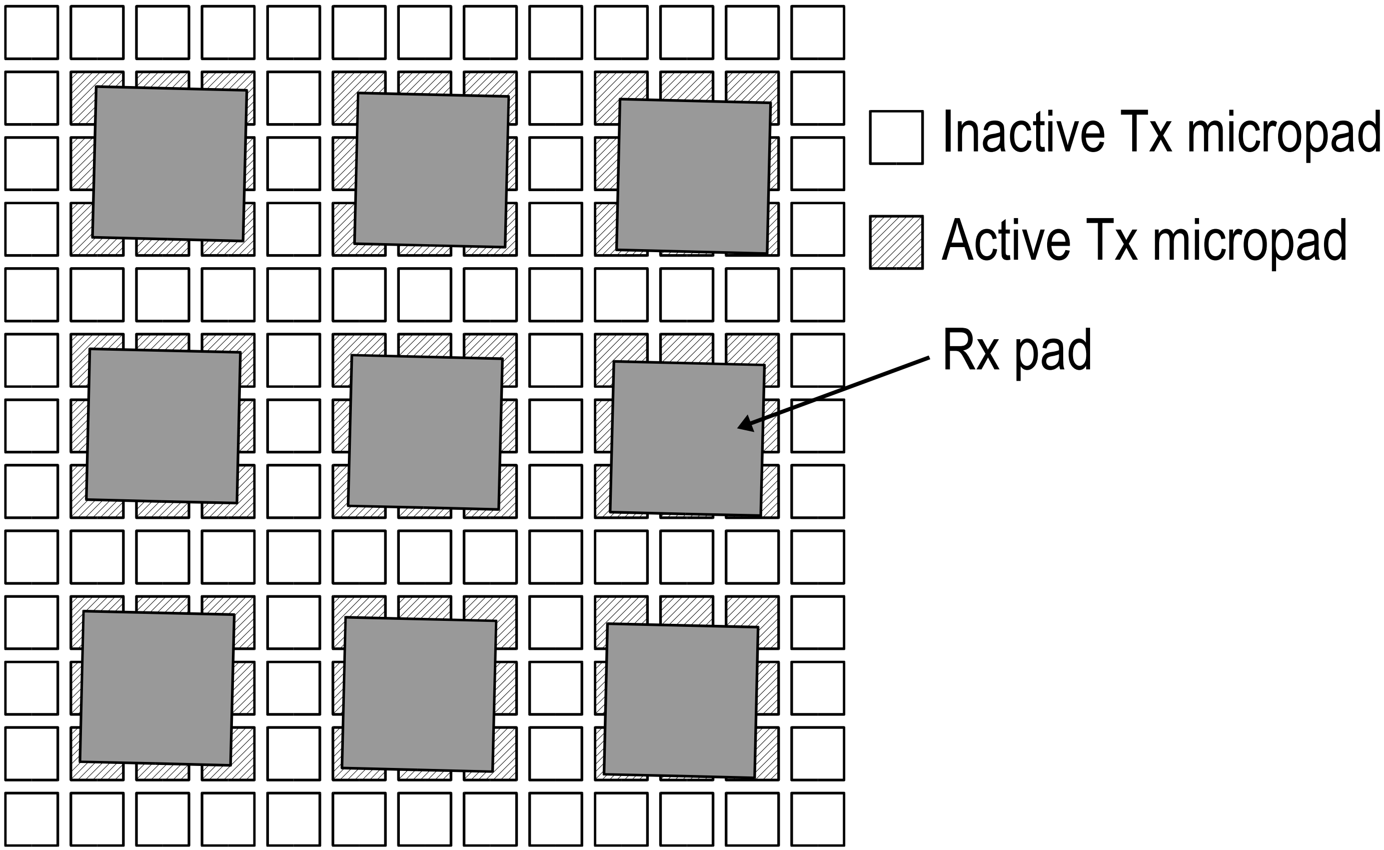
On-chip Alignment Measurement



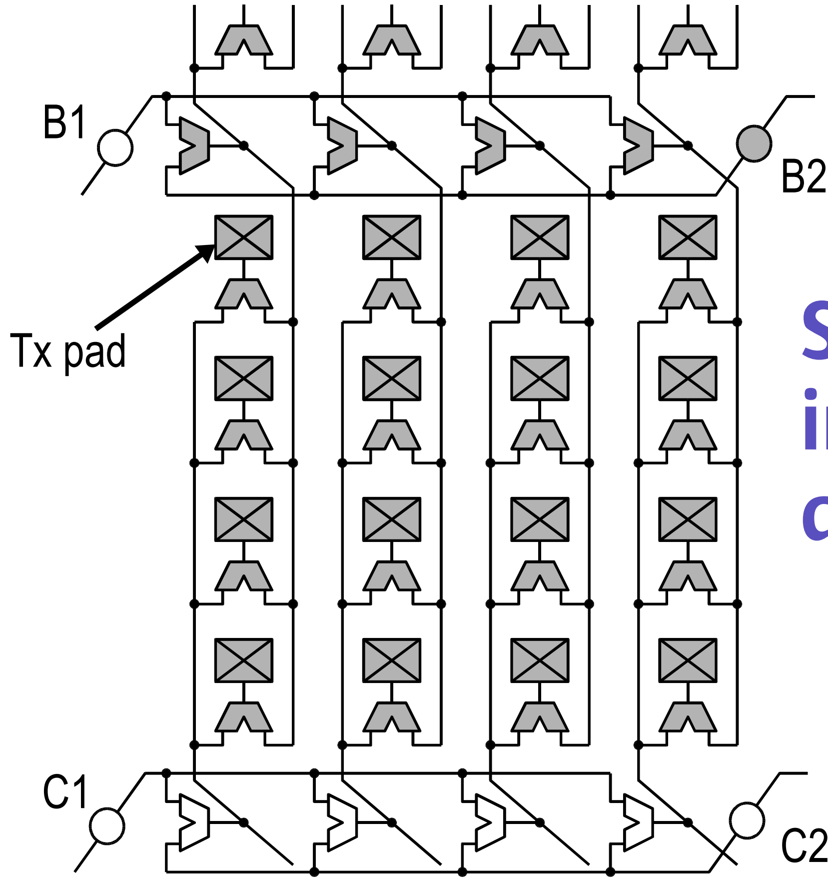
Vernier under Misalignment



Electronic Alignment Top View

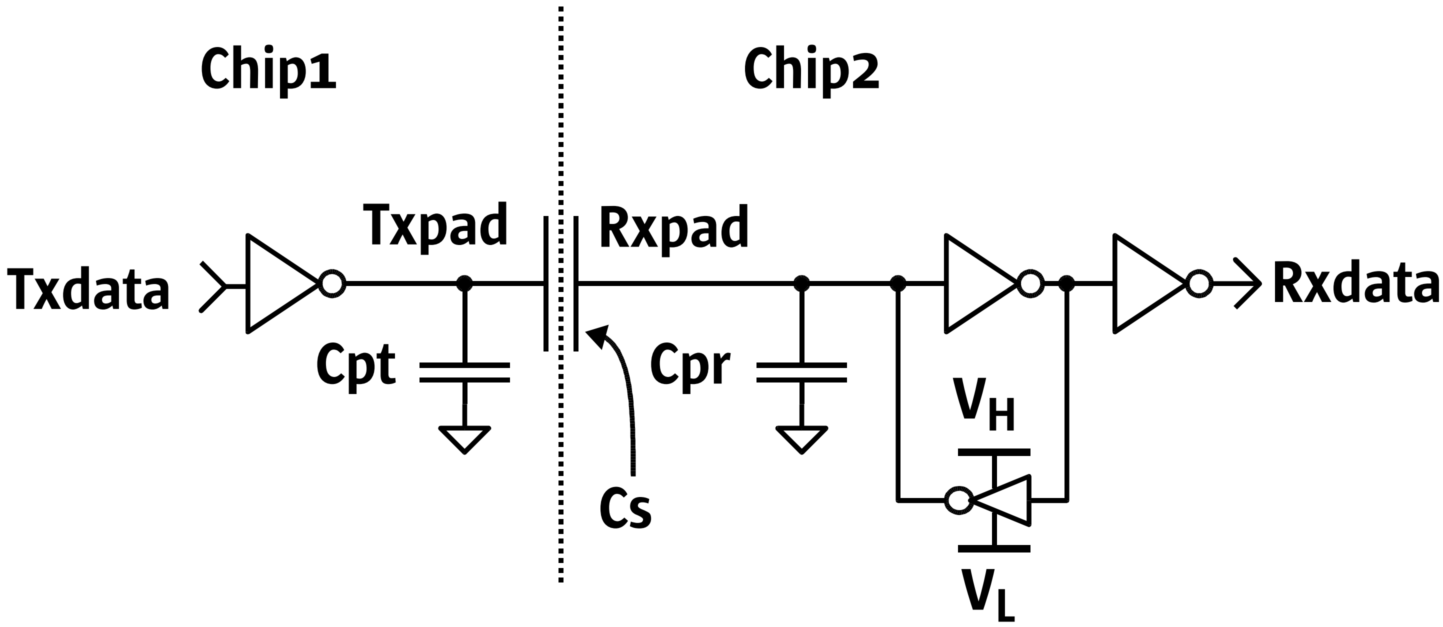


Steering Circuit
One Receiver Pad Pitch

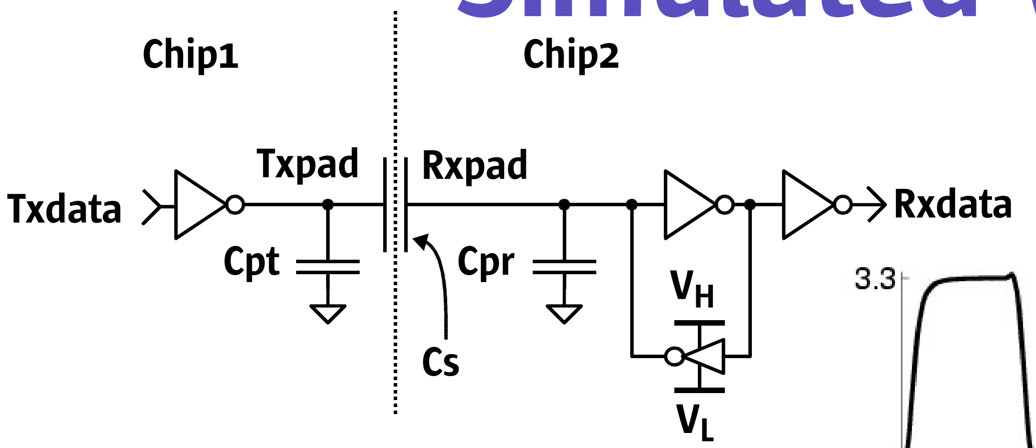


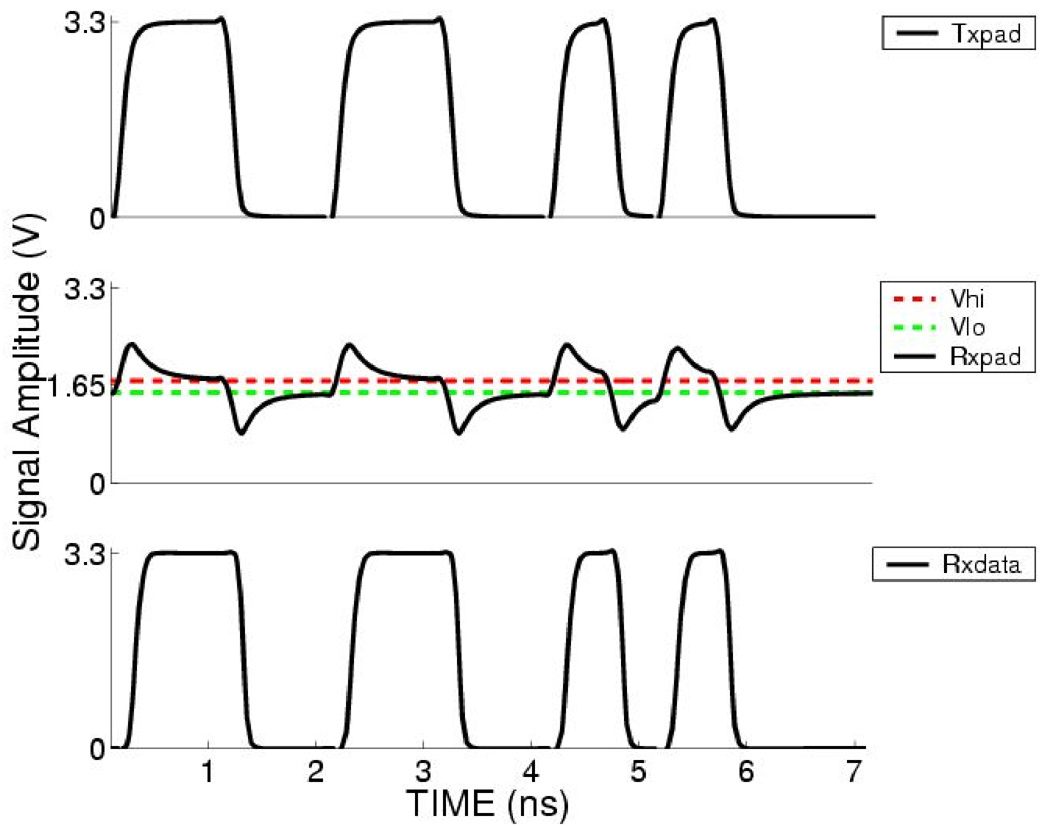
Steering in two dimensions

Transmit/Receive Circuits

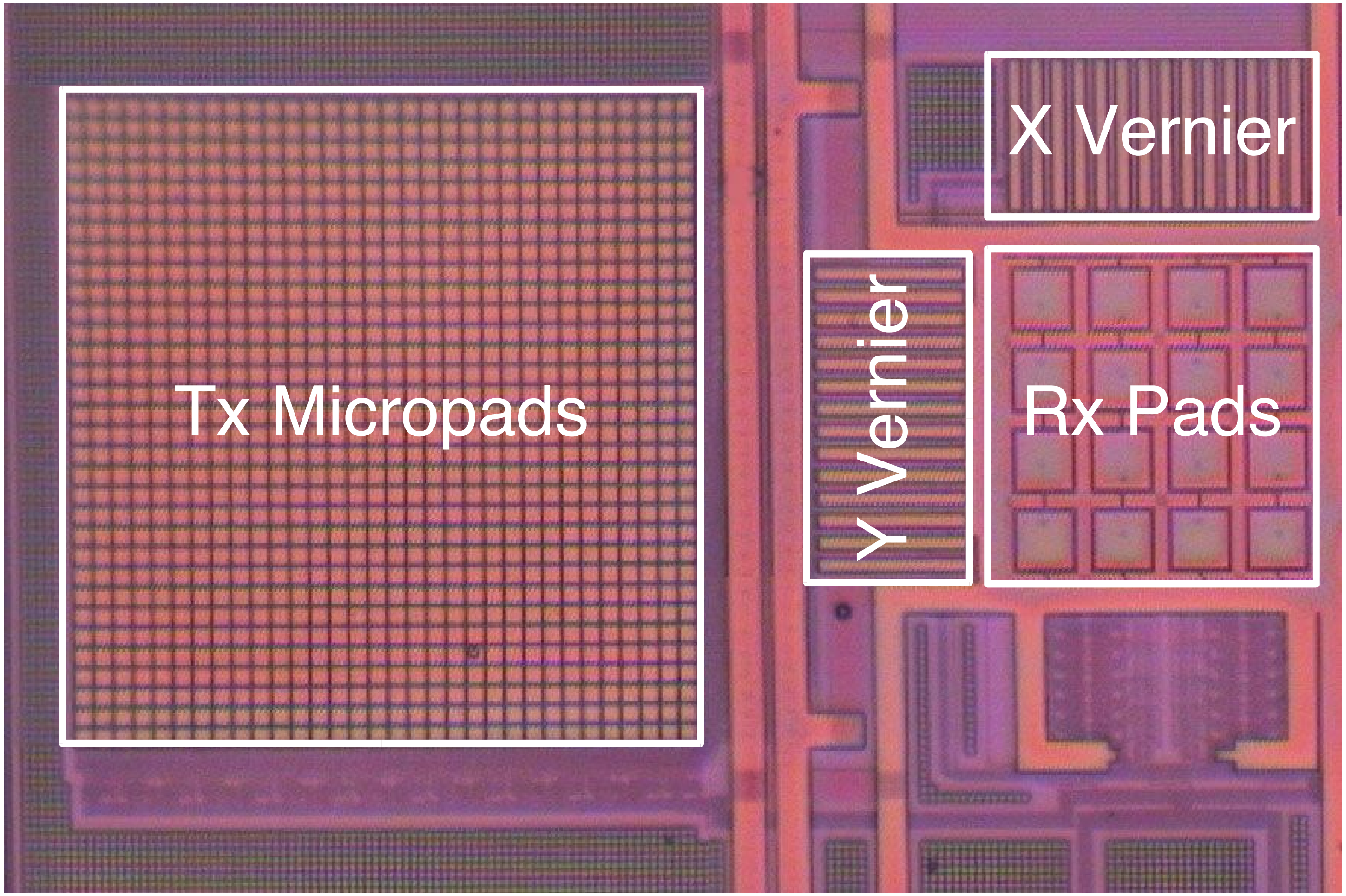


Simulated Waveforms

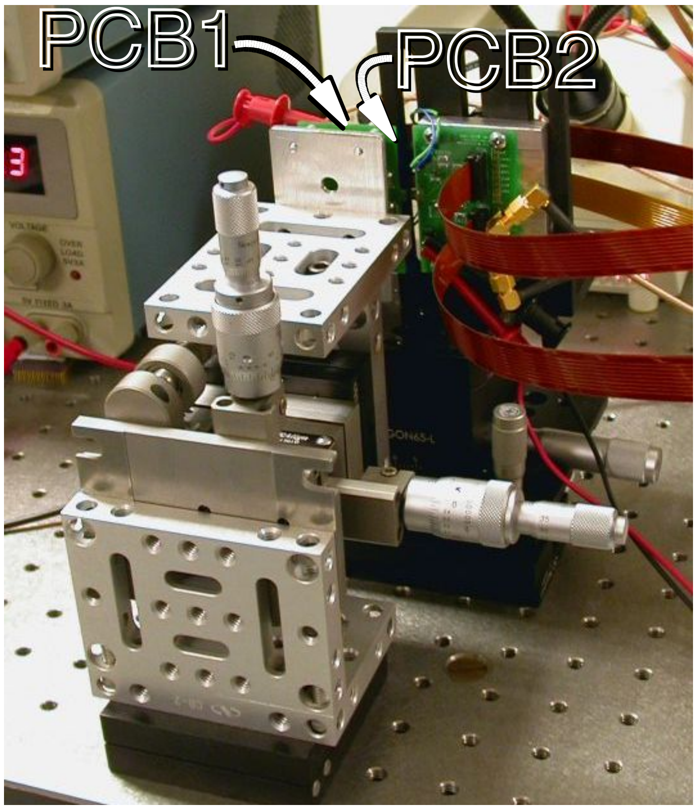


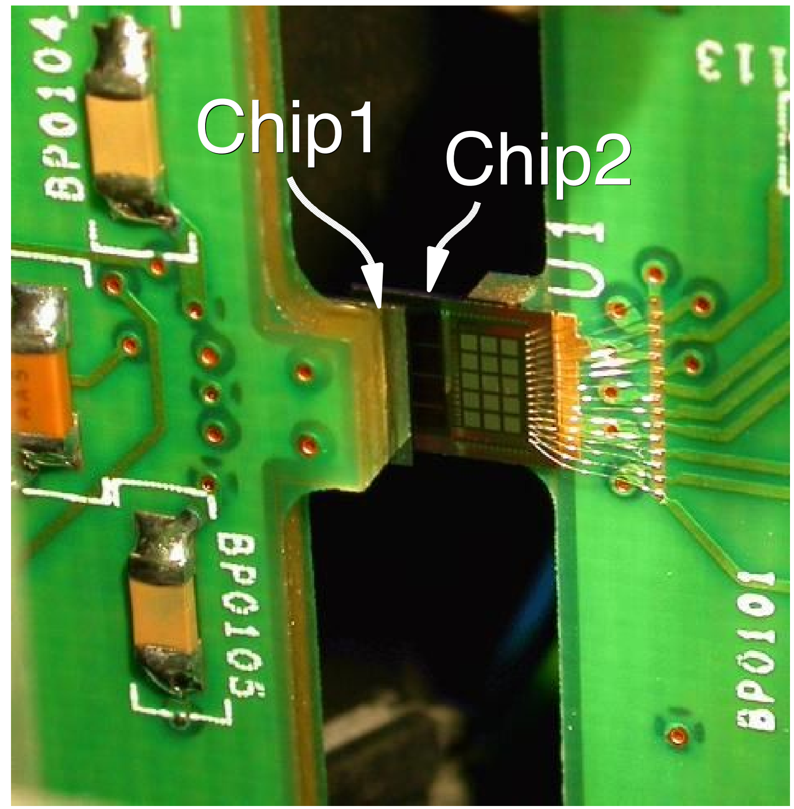


Chip Transceiver Photo



Experimental Setup

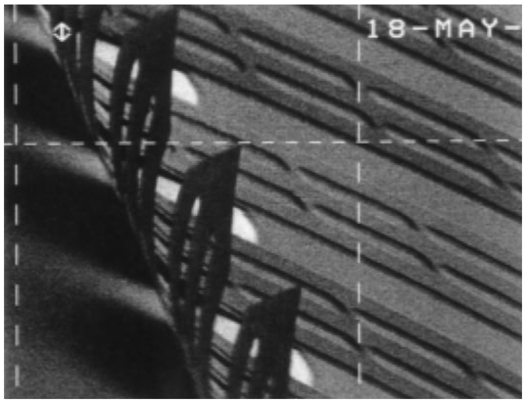




Power Connections

Microspring connectors

(Ref. 3,4)



(Ref. 5)

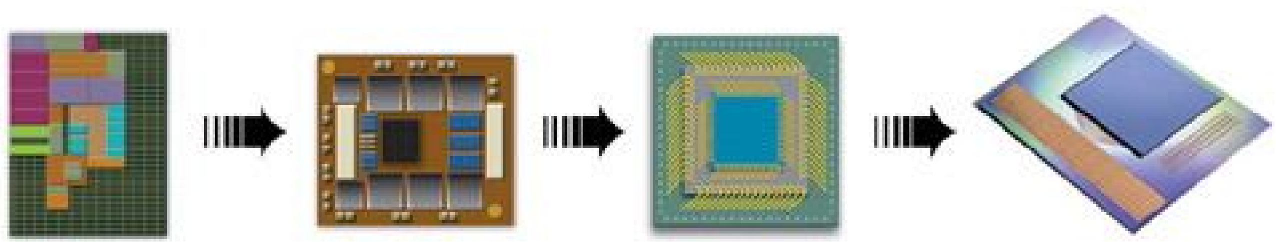
(Ref. 3,4)

or...
Capacitive
or Inductive
Coupling

How does Proximity Communication fit in with industry packaging trends?

Industry Direction: 3-D Integration

- Scaling of chip lithography is limited by wire delay, leakage, and fabrication costs
- Novel packaging improves performance and cost of chips fabricated with existing lithography

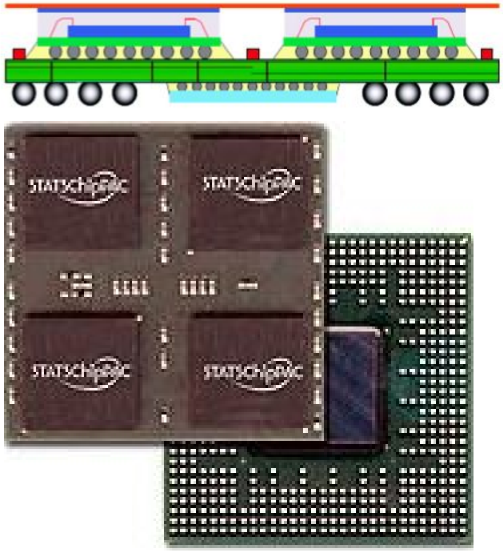


(Ref 7)

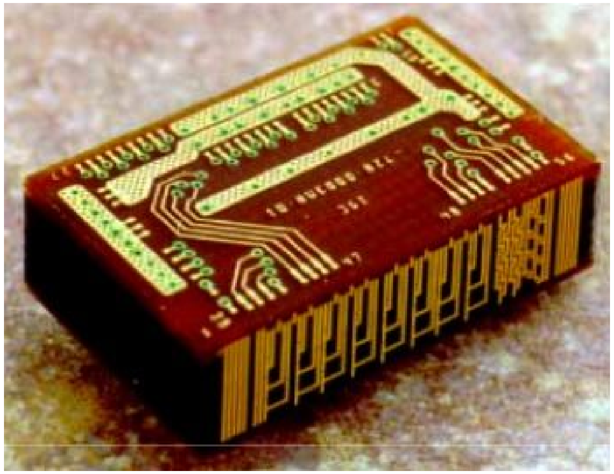
System On chip (SOC)	System In Package (SIP)	Stacked Die Package (SDP)	3-D Integrated Chips (3D-IC)

Integration Examples

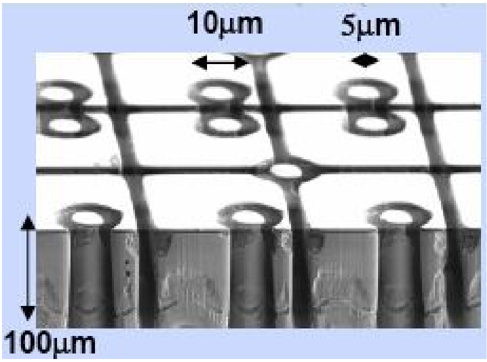
STATS ChipPAC (SIP)



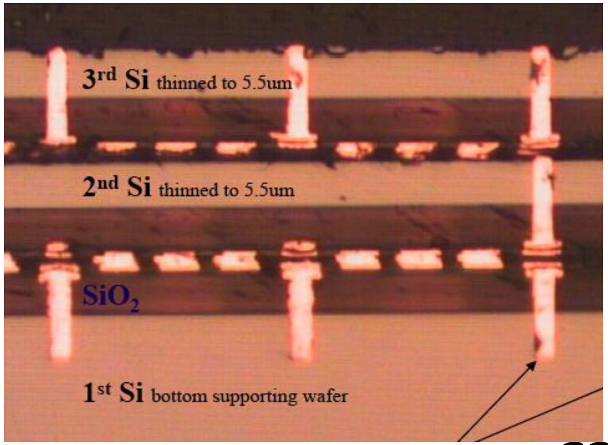
Irvinse Sensors Neo-Stack



Xan3D Thru-chip vias



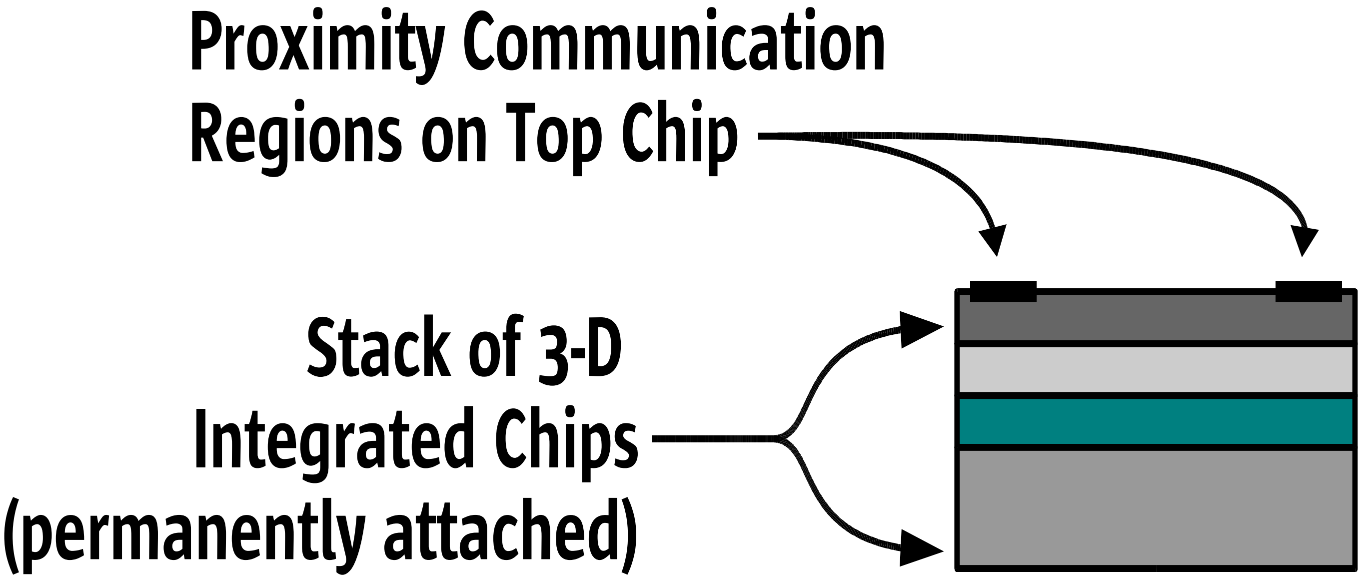
Tezzaron 3D-IC



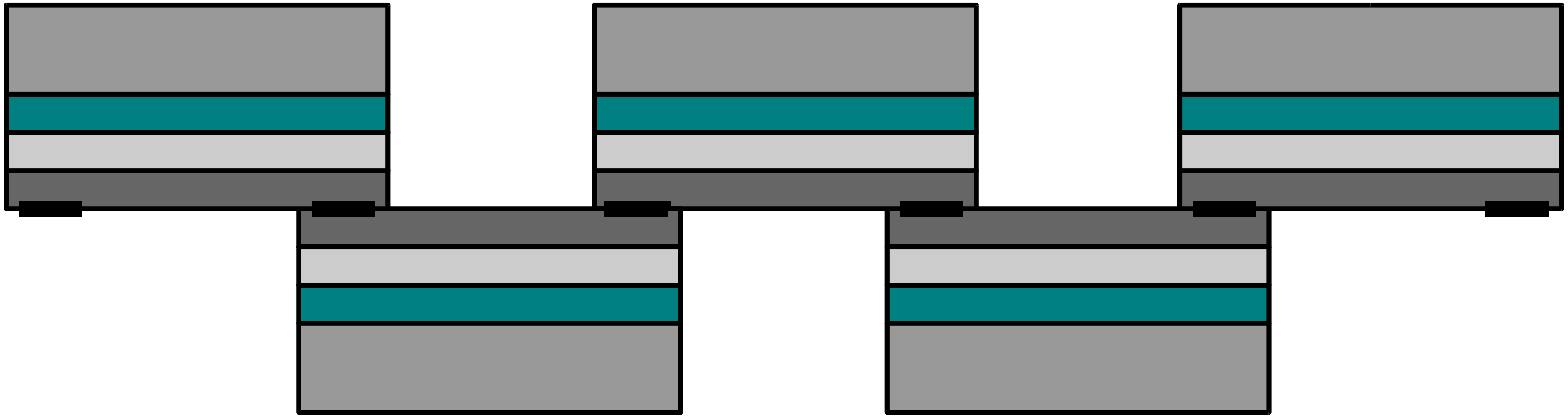
3-D Integration Challenges

- Known-Good-Die problem limits yield
- Merging ICs exacerbates the chip performance versus I/O bandwidth imbalance

3-D + Proximity Communication

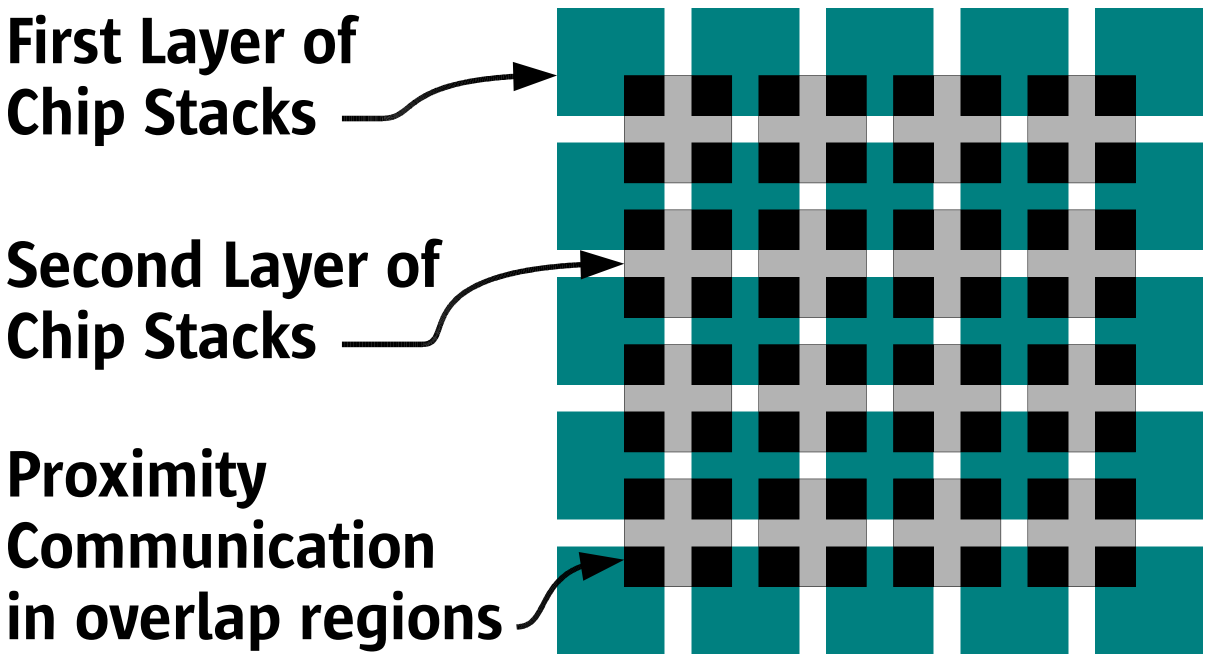


3-D Integration



- 3-D integration provides chip stacks
- Proximity Comm. interconnects the stacks

Wafer Scale Interconnect



Proximity Communication Summary

- Proximity Communication avoids off-chip wires
  - Increases available bandwidth per chip
  - Reduces I/O power
- Avoids permanent attachment
  - Makes chips replaceable, increases yield
  - Enhances testing capability
  - Enables wafer-scale integration

Acknowledgements

Asynchronous Group at Sun Labs

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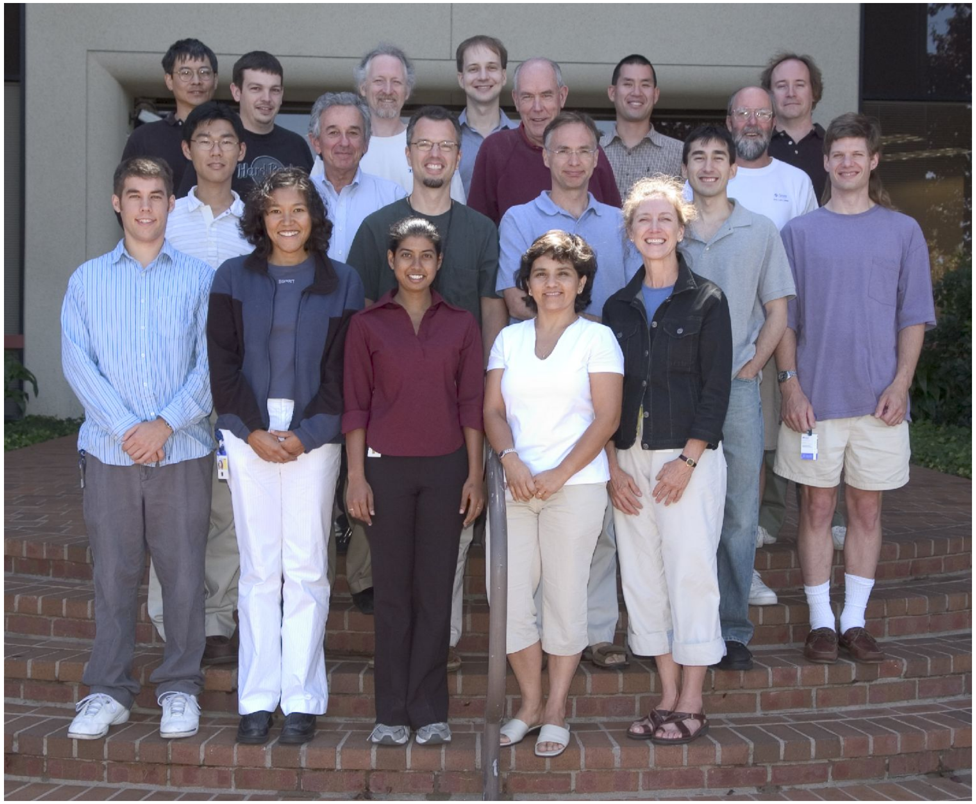

References

(1) R. Drost, R. Ho, R. D. Hopkins, I. Sutherland, "Electronic Alignment for Proximity Communication," *IEEE Int'l Solid-State Circuits Conference*, Feb. 2004.

(2) R. Drost, R. D. Hopkins, I. Sutherland, "Proximity Communications," *IEEE Custom Integrated Circuits Conference*, pp. 469-472, Sept. 2003.

(3) Microspring technology: www.formfactor.com

(4) N.L. Tracy, et al., "Array sockets and connectors using MicroSpringTM technology," *Electronics Manufacturing Technology Symposium IEEE*, pp. 129-140, Oct 2000.

(5) D. Smith and S. Alimonda, "A New Flip-Chip Technology for High-Density Packaging," *Proc. 46th Electronic Components and Technology Conf.*, May 1996.

(6) J.L. Hennessy and D.A. Patterson, Computer Organization and Design, 2nd ed., Morgan Kaufmann Publishers, San Francisco, 1997.

(7) www.xan3d.com

(8) www.irvine-sensors.com

(9) www.statschippac.com

(10) www.tezzaron.com

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http://research.sun.com/async

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Communicating Time