IMAPS

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Technology Review of System-in-Package

Presented

by

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Overview

- Moore's Law – "More Moore" and "More than Moore"
- System-in-Package (SiP) definition
- Comparison of advanced packaging technologies
- Brief history of SiP
- SiP opportunities, challenges and solutions
- Market for SiP and main players
- Inside the devices
- Summary

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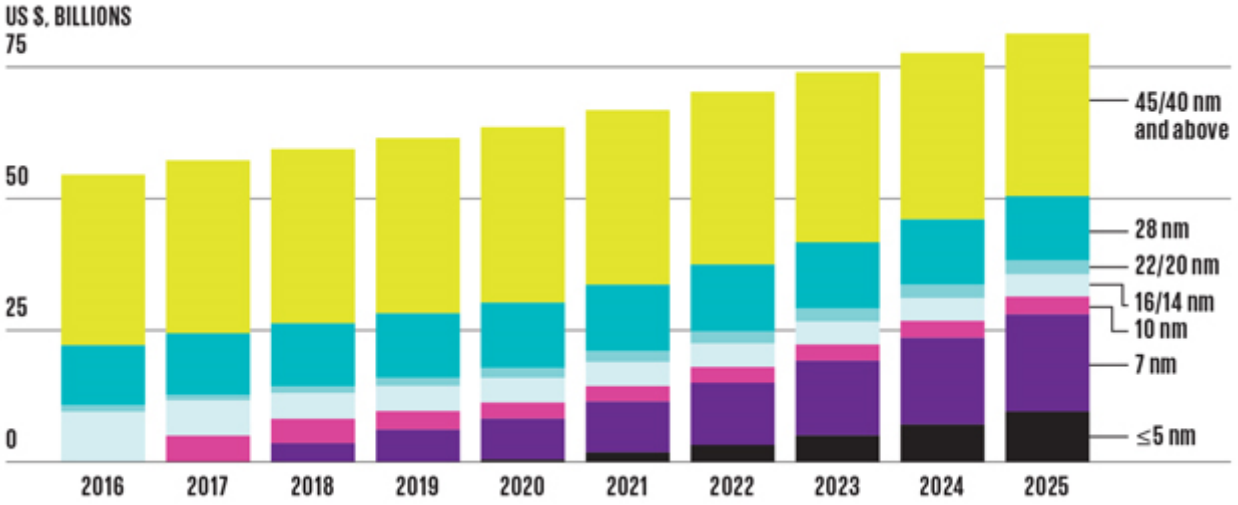
Moore's Law

- Is it dead? – No!
- It has slowed down
- Cost is increasing
- "More Moore" or "More than Moore" ?



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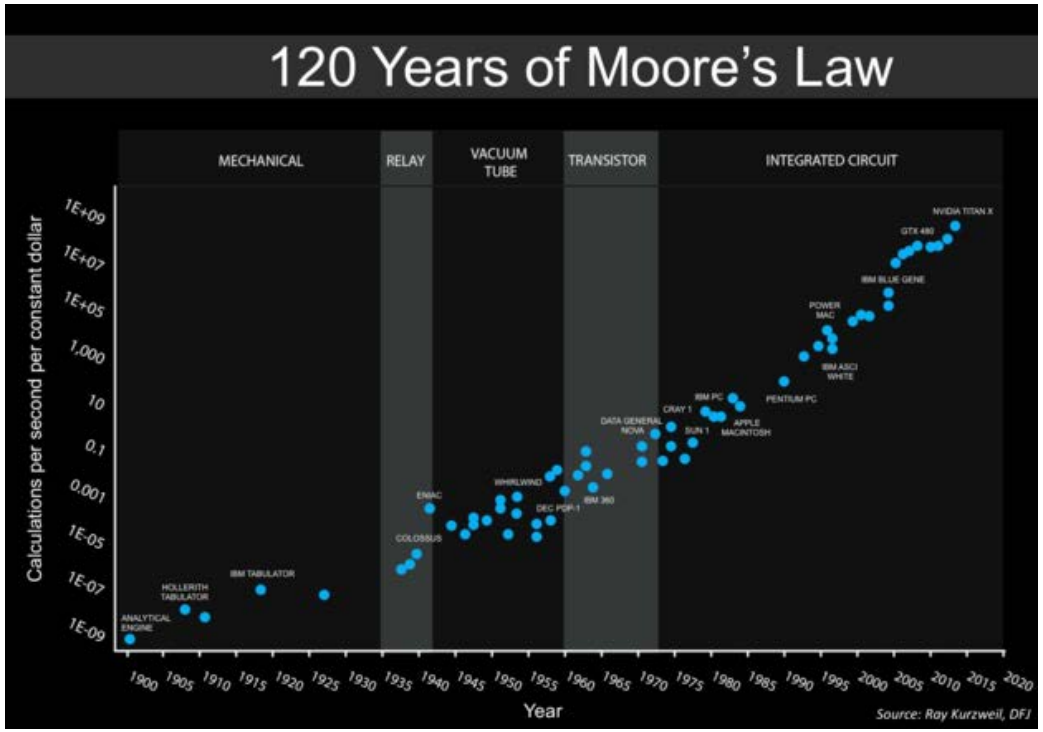

Source: Ray Kurzweil, DFJ

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System-in-Package

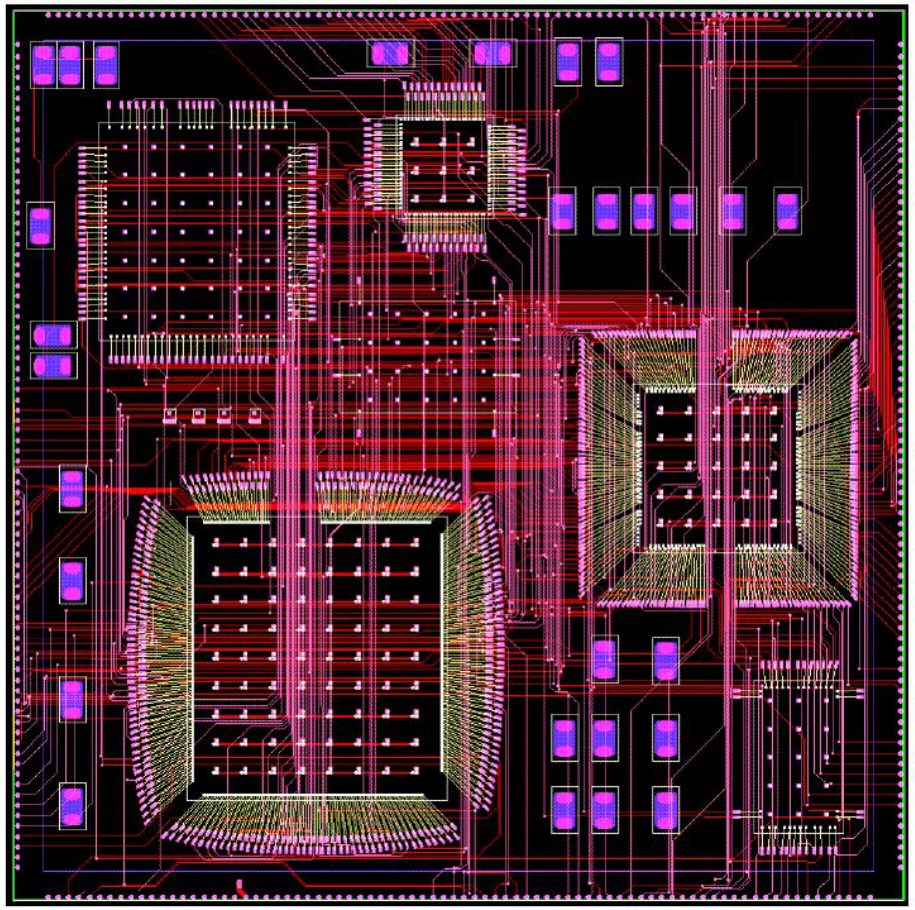

Fig. 1 Complete Pentium Computer in a System-in-Package(SiP) design: CPU, RAM and graphics [1]

- Number of ICs enclosed in a single module
- Integration of ICs, passives, active components, devices like MEMS or optical components
- Components that provide Multiple functions associated with a system
- SiP is used in mobile devices, medical devices ,IoT ,wearables, etc.

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Comparison of Packages

SOC
- Intellectual property (IP) and legal issues
- Time-to-market is high

SiP
- Heterogeneous Package
- Reduced time-to-market
- Small form factor

Advanced Packaging

MCM
- Better than SoC
- Capital-intensive
- Technology-complex

SoP
- Integration of thin-film components
- Minimize latency effect
- Greater PCB space savings

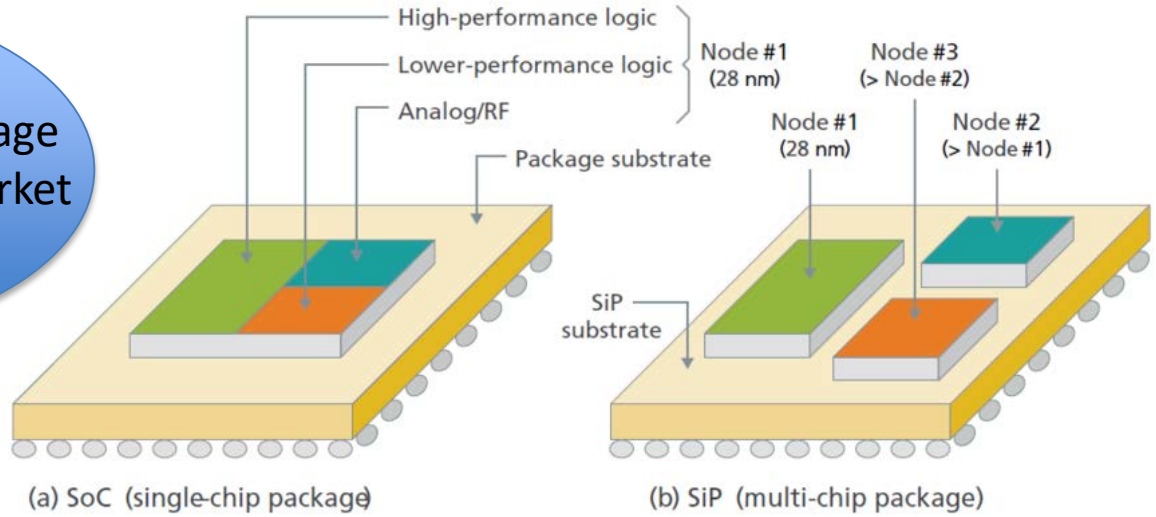

Fig. 2 System-on-chip (SoC) compared to System-in-Package (SiP)

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History of SiP

- An insightful reading of “Historical Perspective of System in Package (SiP)” by Dr. Dai
- Profound contributions by Prof. Ernest Kuh
- The term “System-in-Package” was promoted in 2000
- SiP design, analytical methods, and CAD tools
- Solder bumping and FC assembly platforms for SiP
- Wafer level package (WLP) – Advanced packaging

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Why SiP?

- More than Moore
- System Integration
- Cost reduction
- Performance Boost
- Functionality Boost

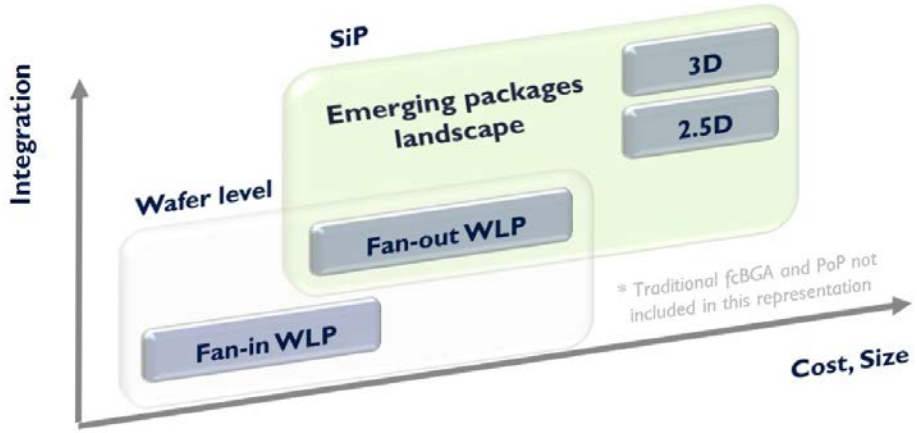

Fig. 3 Growth of advanced packaging [2]

Mobile sector is driving production and growing, however, a new market driver – IoT is on the horizon and is expected to have a significant impact on the packaging industry as a whole – Yole Development

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Opportunities

“Smaller, faster, cheaper”

- Reduced time-to-market
- The modules and main system assembly can be developed concurrently
- Compatibility with die design and integration of various die technologies
- Reduced system board space and complexity and layer count by moving to SiP solution

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Challenges

- Managing substrate complexity
- Design Challenges
- Known-good-die (KGD) issue
- Interconnect Challenges
- Thermal Management
- Test Challenges

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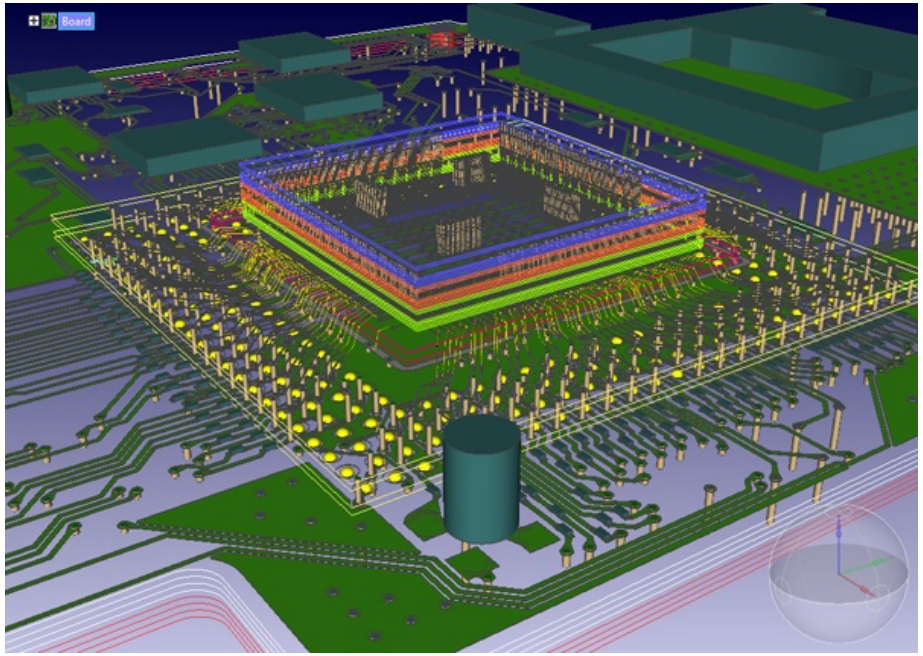
SiP Design Challenges

- Several optimization problems:
  - System I/O requirements
  - Thermal and signal integrity constraints
  - Die placement and orientation
  - Stacking configurations
  - Package substrate and interposer design
  - interconnect design
- Floor-planning
- Design tools



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Thermal and Test Challenges

- Need of Thermal Solutions
- ITRS Roadmap
- Thermal Solutions by Amkor
- Test Cost
- Time-to-market

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SiP Solutions

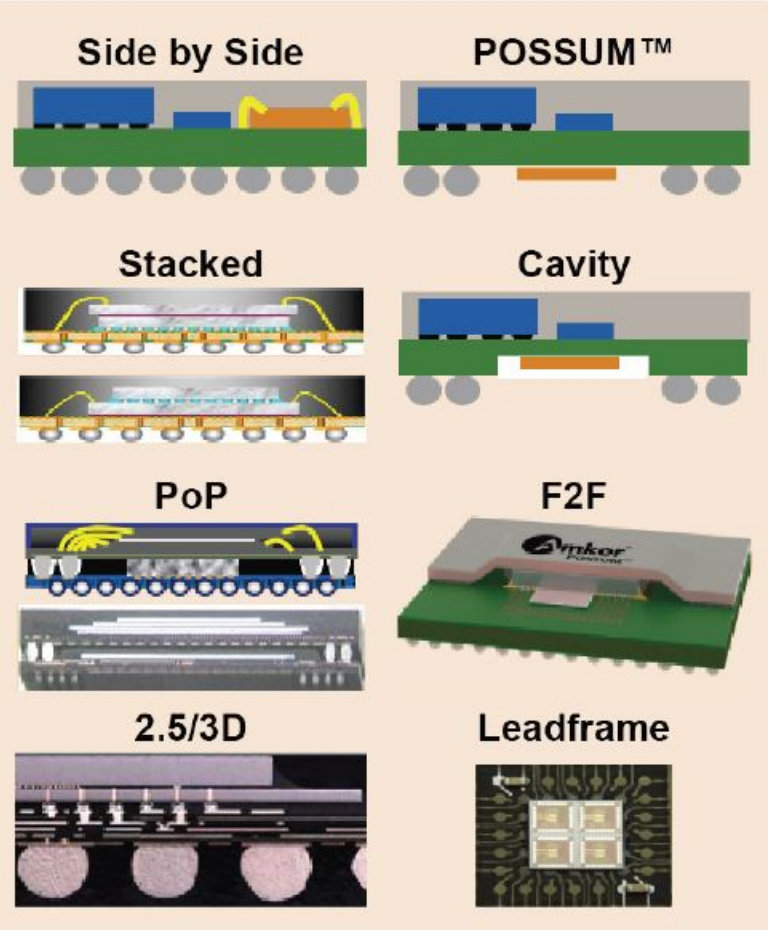

Fig. 4 SiP module design options [3]

- Surface mount discrete passive
- Integrated passive devices (IPD), either glass or silicon (Si) type
- Passives embedded inside or patterned on the substrate
- Die embedded in the package substrate
- Surface acoustic wave (SAW)/bulk acoustic wave (BAW) filters, crystals, oscillators, antennas
- Sputtering conformal shielding and compartmental conformal shielding
- Core and coreless substrate
- Recessed and cavity substrate
- Doubled side mold
- Double-sided assembly (POSSUM™)
- Strip grinding fine pitch ultra-thin package
- Different ICs integrations (Silicon, GaAs, SiGe)
- Pre-packaged ICs
- Connectors
- Mechanical parts

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Market for System-in-Package

- RF and wireless devices

  Power amplifiers, front end module, antenna switch, GPS/GNSS modules, cellular handset and cellular infrastructure, Bluetooth® solutions

- Solid-state drives (SSDs)

  Storage for tablets, net books and computing applications where typical SSDs include controller ASIC, NAND, DDR, logic and power circuits

- Automotive applications

  Under-hood electronic control unit (ECU), sensory modules and infotainment

- IoT for wearable and machine to machine (M2M) products

  Connectivity, MEMS, sensors, microcontroller, power management and other mixed-signal devices

- Power modules

  DC/DC converter, LDO, PMIC, battery management and others

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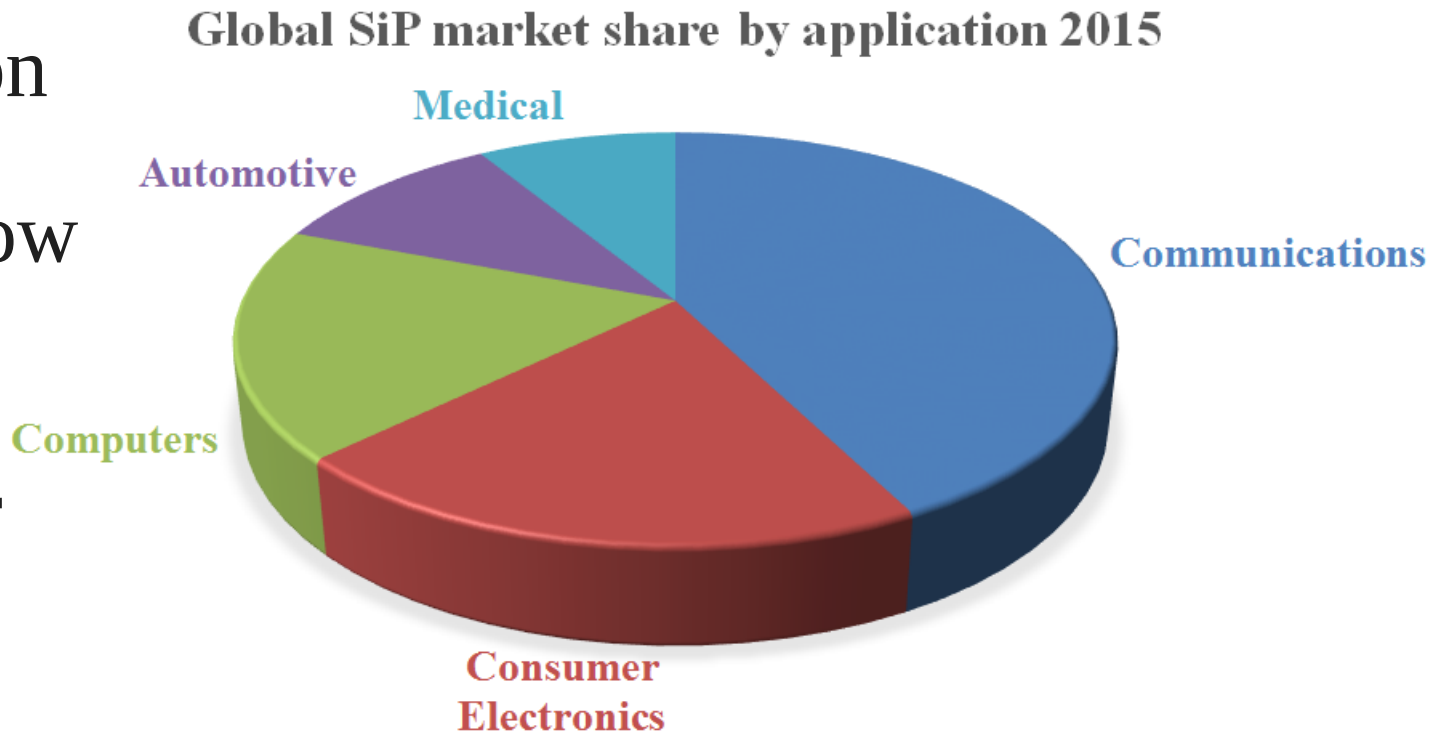
Market Report

- SiP market by application
- Global SiP market to grow at a CAGR > 10 %
- Major application sector



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Market Players

- Amkor Technology
- ASE
- Jiangsu Changjiang Electronics Technology (JCET)
- Siliconware Precision Industries (SPIL)
- United Test and Assembly Center (UTAC)

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3D TSV System-in-Package for Aerospace application

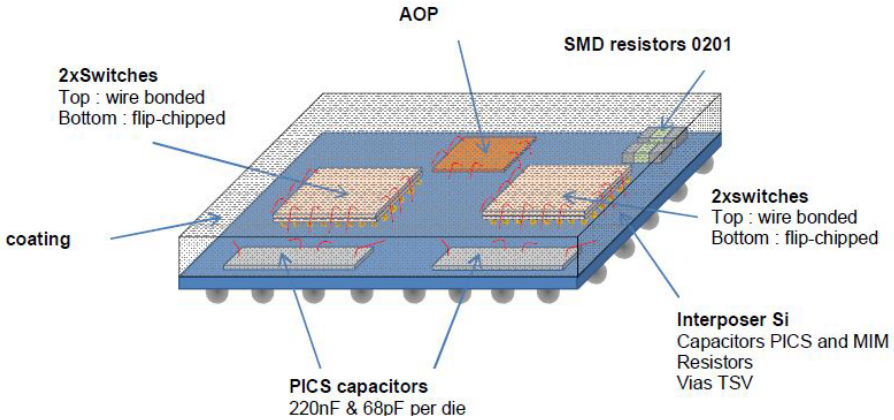

Fig. 5 Schematic view of 3D SiP [4]

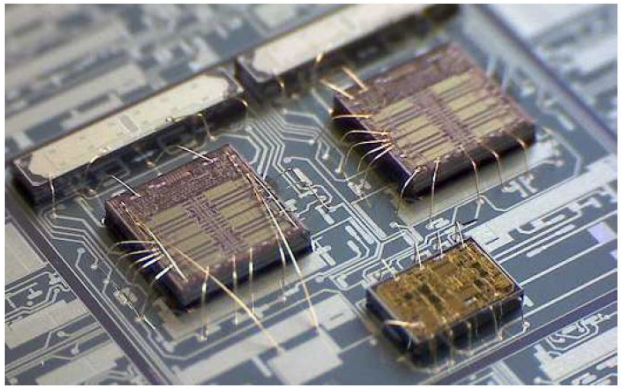

Fig. 6 Overview of an SiP [4]

Intel's 3D System-in-Package Technology

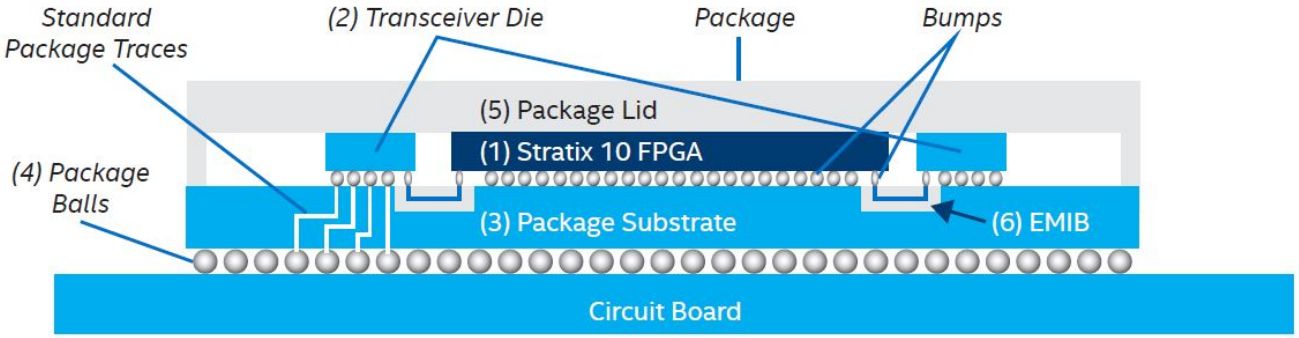

Fig. 7 Heterogeneous Integration using EMIB Technology [5]

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Miniaturization of System-in-Package for wearables

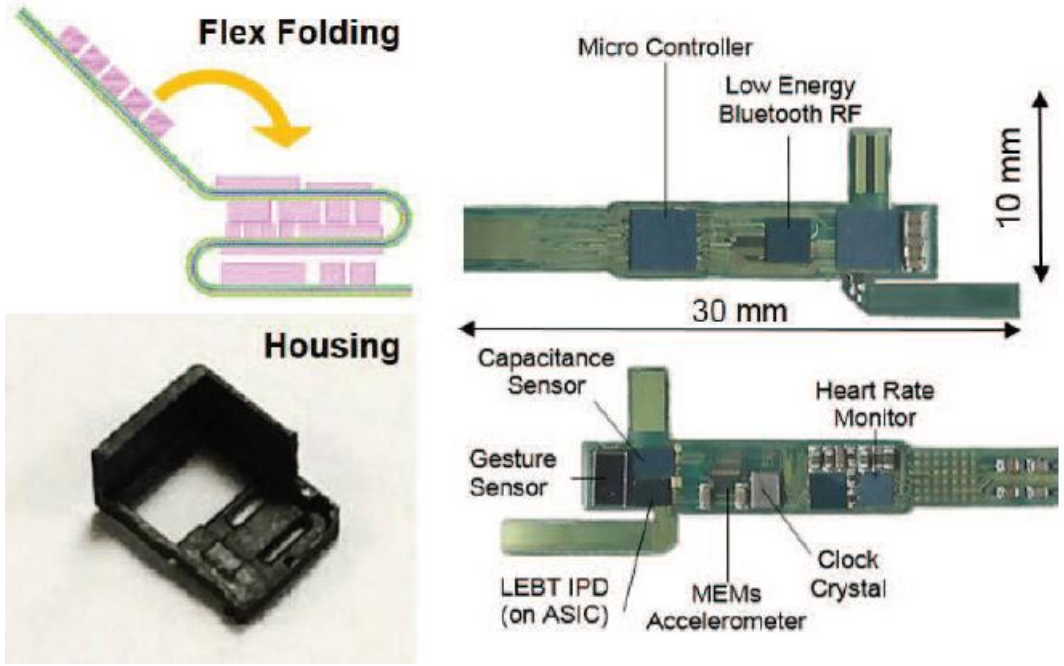

Fig. 8 Health monitoring module using Cu pillar solder flip chip with size reduction from 30 x 10mm to 6 x 4 x 2.6mm after folding the flex to the septum [6]

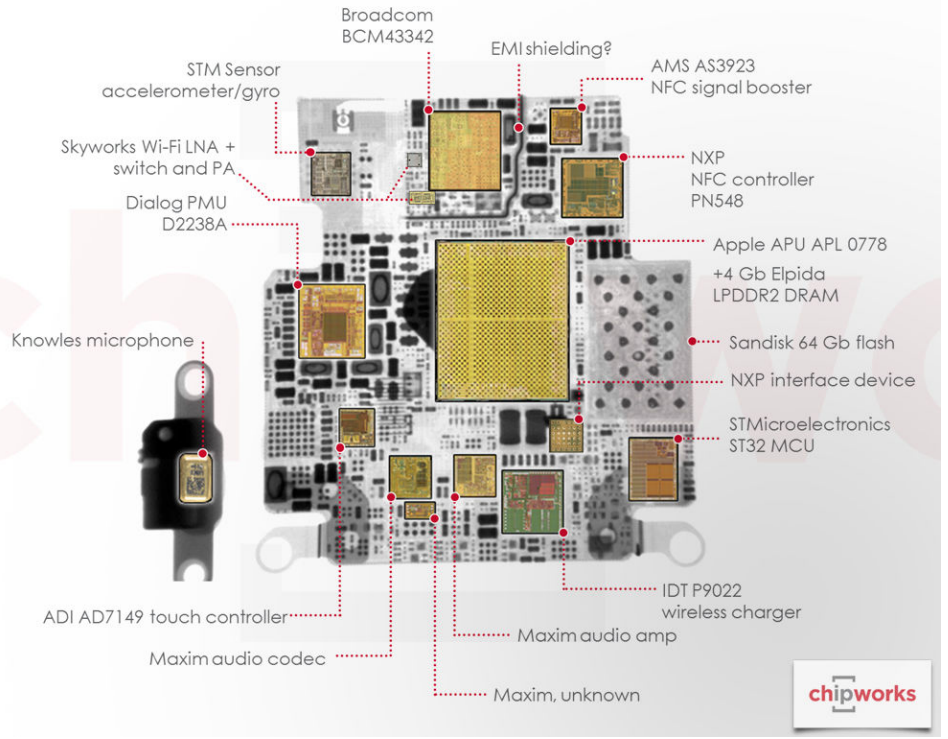

Fig. 9 Apple watch S1 System-in-Package

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Summary

- System-in-Package remains a viable interim solution to the inevitability of SoC manufacturing
- Shorter time-to-market and reduced production cost are the key considerations of SiP
- The main advanced packaging technology drivers and innovation: Increased integration, small form factor and low cost
- Reviewed SiP solutions, market, and application

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