

Apple M1 System-on-Chip

A deep-dive analysis of Apple's first in-house CPU for Mac.



Two new Apple MacBook models and the Mac mini are now powered by an Apple in-house System-on-Chip (SoC) design: the M1. The transition from Intel x86 processors has created shockwaves felt throughout the processor and computing world. This new, first SoC for Mac features 4-CPU high-performance cores, 4-CPU high-efficiency cores, and 8-GPU cores. The tight software-hardware integration inside Apple enabled a compact, efficient processor for personal computer that outcompetes many premium microprocessors. 16 billion transistors using TSMC 5nm process were used to build it.

To reveal all the details of this new, exceptional SoC, this report features multiple analyses: a floor plan analysis to understand the high-level chip architecture with IP block area contribution measurements, a front-end construction analysis that reveals the most interesting features of the new TSMC 5nm process, a back-end construction analysis of the packaging structure, and a detailed manufacturing cost analysis.

On the SoC side, it appears that the die area of the M1 was optimized for functionality rather than SRAM cache. There is limited on-chip cache, taking cues from mobile SoC designs relying on the universal memory architecture (UMA) concept and external LPDDR4X DRAM.

Significant die area is devoted to standard cell functions, indicating that Apple is leveraging in-house chip design to optimize hardware for the operating system.

On the packaging side, the same structure is used for Apple's A12X and A12Z, with the integration of the DRAM on the SoC substrate, and embedded silicon capacitors in the substrate.

Along with a complete construction analysis using SEM cross-sections, materials analyses, and delayering, the front-end analysis employs a high-resolution TEM cross-section to expose the high mobility channel of the 5nm process, and the back-end analysis uses CT-Scan (3D X-ray) to reveal the layout structure of the package.

COMPLETE TEARDOWN WITH

- Detailed photos
- Floor plan analysis
- Precise measurements
- Materials analysis
- Front-end structural analysis with TEM
- Back-end structural analysis with CT-Scan
- Supply-chain evaluation
- Manufacturing cost analysis

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AUTHORS



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Stéphane Elisabeth, PhD has joined System Plus Consulting's team in 2016. Stéphane is Expert Cost Analyst in RF, Sensors and Advanced Packaging. He holds an Engineering Degree in Electronics and Numerical Technology, and a PhD in Materials for Microelectronics.



Don Scansen has partnered with System Plus Consulting to launch the new die architecture and front-end process analysis of advanced SoC devices including APU, CPU, GPU, and FPGA. Don previously supported clients ranging from individual patent owners to Fortune 500 companies providing competitive analysis and intellectual property support. He holds a PhD in electrical engineering.

Also :

- **Véronique Le Troadec** - Senior Lab Analyst - System Plus Consulting

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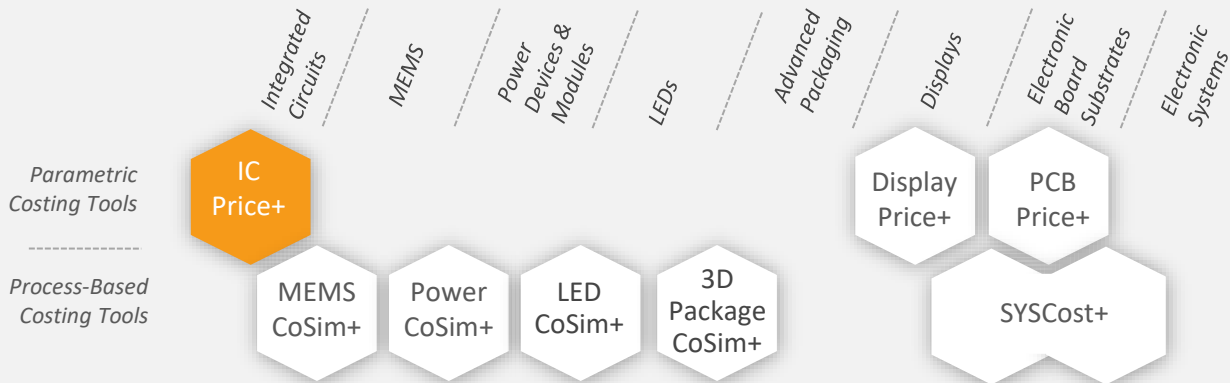


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2.4 The mailing is operated through electronic means either by email via the sales department or automatically online via an email/password. If the Product's electronic delivery format is defective, the Seller undertakes to replace it at no charge to the Buyer provided that it is informed of the defective formatting within 90 days from the date of the original download or receipt of the Product.

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3.2 Payments due by the Buyer shall be sent by cheque payable to Yole Développement, credit card or by electronic transfer to the following account:

HSBC, 1 place de la Bourse 69002 Lyon France

Bank code: 30056

Branch code: 00170

Account n°: 0170 200 1565 87

BIC or SWIFT code: CCFRFRPP

IBAN: FR76 3005 6001 7001 7020 0156 587

To ensure the payments, the Seller reserves the right to request down payments from the Buyer. In this case, the need of down payments will be mentioned on the order.

3.4 Payment is due by the Buyer to the Seller within 30 days from invoice date, except in the case of a particular written agreement. If the Buyer fails to pay within this time and fails to contact the Seller, the latter shall be entitled to invoice interest in arrears based on the annual rate Refi of the «BCE» + 7 points, in accordance with article L. 441-6 of the French Commercial Code. Our publications (report, database, tool...) are delivered only after reception of the payment.

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4.2 The Seller shall only be liable for (i) direct and (ii) foreseeable pecuniary loss, caused by the Products or arising from a material breach of this agreement

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- a) Damages of any kind, including without limitation, incidental or consequential damages (including, but not limited to, damages for loss of profits, business interruption and loss of programs or information) arising out of the use of or inability to use the Seller's website or the Products, or any information provided on the website, or in the Products;
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4.8 The Seller does not make any warranties, express or implied, including, without limitation, those of sale ability and fitness for a particular purpose, with respect to the Products. Although the Seller shall take reasonable steps to screen Products for infection of viruses, worms, Trojan horses or other codes containing contaminating or destructive properties before making the Products available, the Seller cannot guarantee that any Product will be free from infection.

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