The next step for power-efficient memory performance in client laptops

LPDDR5X CAMM2 (LPCAMM2) is Micron's new, compact modular memory solution that enables platform designers with an innovative form factor, based on low-power double data rate 5X (LPDDR5X), to create thin and light laptops that are both high-speed and power-efficient.[1]

Designed to overcome the limitations of SODIMMs, LPCAMM2 helps to solve key issues that laptop designers face: the performance, power, and space challenges of SODIMMs, and the fixed memory solution of LPDDR soldered down to the motherboard.

LPCAMM2 leverages Micron's LPDDR5X SDRAM in a modular form factor to enable a configurable, fast, and power-efficient memory solution, enabling users to enjoy higher performance and longer battery life.

To create more space and flexibility for designers, the LPCAMM2 module is compressed against a connector that interfaces with the motherboard. This design results in a smaller footprint (total volume on the motherboard) and shorter traces to achieve faster speeds. Additionally, a compact modular form factor enables designers to service, upgrade, and configure their memory solutions, creating more options than laptop designs that have LPDDR soldered down to the board.

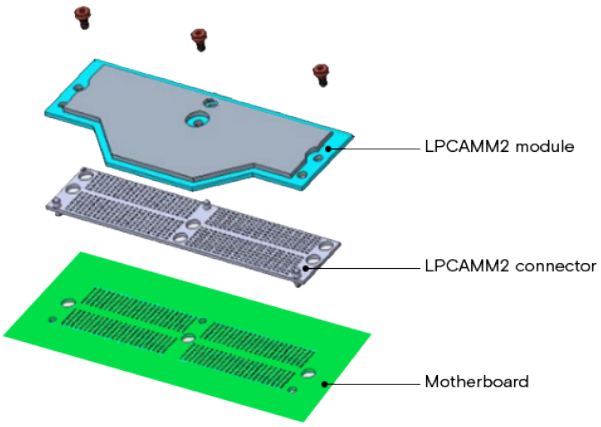

Figure 1. LPCAMM2 module, connector, and motherboard

Key benefits

Designed for client laptops

Optimized for laptops that need maximum performance and low power when in both active and standby modes.

1.5X

LPDDR5X on LPCAMM2 modules can scale memory speed up to 9.6 Gb/s (1.5X speed up), providing superior performance for client applications.[2]

64%

More than 60% space savings.[3]

A compact modular form factor (compression-attached) saves space and enables customers with more flexible design choices.

57–61%

Active power up to 61% lower per 64-bit bus at the same DDR5 speed.[4]

Significant power savings in system standby (80%) to prolong battery life.[4]

1. Lower Power (LP). Compression-attached memory module (CAMM). 2 (2nd generation).
2. As compared to commercially available competitive DDR5 SODIMMs. 1.5X speed up based on a calculation between a 6.4 Gb/s SODIMM to a 9.6 Gb/s LPCAMM2.
3. Calculation based on comparison of the total volume of commercially available dual-stacked DDR5 SODIMM (32,808 mm^3) to LPCAMM2 (11,934 mm^3).
4. Empirical data measured by Micron labs comparing DDR5 at 4800 MT/s to LPDDR5X at 4800 MT/s. Results show 57% lower power for both PCmark 10 and Cinebench and 61% lower power for AI-Benchmark.

High speed, thin, and light design

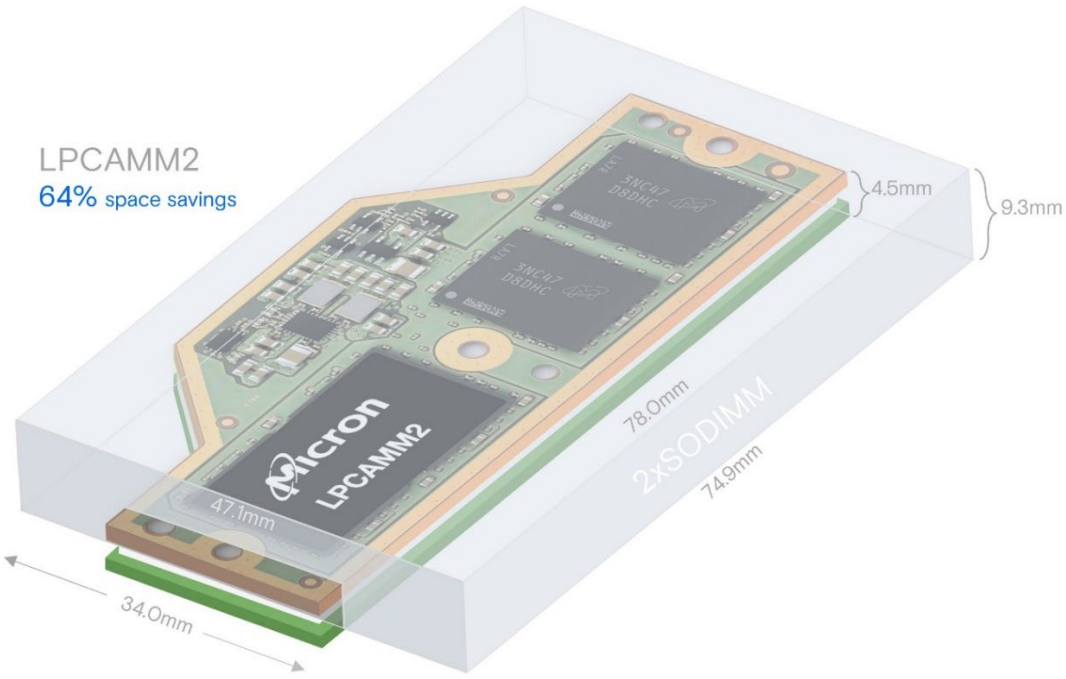

Figure 2: LPCAMM2 vs. SODIMM space savings

Speed

The industry's fastest, low latency LPDDR5X, based on Micron's 16Gb die (1-beta technology), will be available in speeds up to 9600 MT/s, enabling future generations of client platforms.

Capacity

Compared to DDR5, LPDDR5X allows more die to be stacked per package, which enables the full range of memory capacities offered by LPCAMM2 with only four package placements. Unlike SODIMMs, where additional modules must be added to increase capacity, the capacity of LPCAMM2 can be increased without changing the size of the form factor.

Space savings

Customers can utilize the space saved by LPCAMM2 to be more creative when laying out components on the motherboard, enabling the design of thinner and lighter laptops.

Figure 2 shows a volume (mm^3) comparison to scale, where LPCAMM2 is placed inside a dual-stacked SODIMM (gray volume)[3].

Product Specifications	
Max Data Rate	Up to 9.6 Gb/s
Nominal Voltage (V_{DD}/V_{DDQ})	1.05V / 0.5V
Device Width (I/O)	x8/x16
Burst Length	16,32
Internal Banks	16
Bank Groups	4
DRAM Die Density	16Gb
Module Capacity	16GB, 32GB, 64GB
Energy per Bit	4pJ/bit
Self-Refresh Power	<1mW
Operating Temperature	0–85°C
DRAM Component Package Size	12.4mm x 15.0mm x 1.1mm

Performance

Compared to DDR5 SODIMMs, LPCAMM2 operates at higher speeds while consuming less power, providing best-in-class performance per watt in a modular form factor.

The figure below shows performance subscores for the three test groups that make up the PCMark 10® benchmark: digital content, productivity, and essentials.[5] As compared with SODIMM, LPCAMM2 performed better in all test groups, achieving up to 71% better performance based on the Essentials category. The higher scores achieved for all test groups, which are representations of real-world workloads such as video conferencing and photo editing, demonstrate how LPCAMM2 can provide a better user experience.

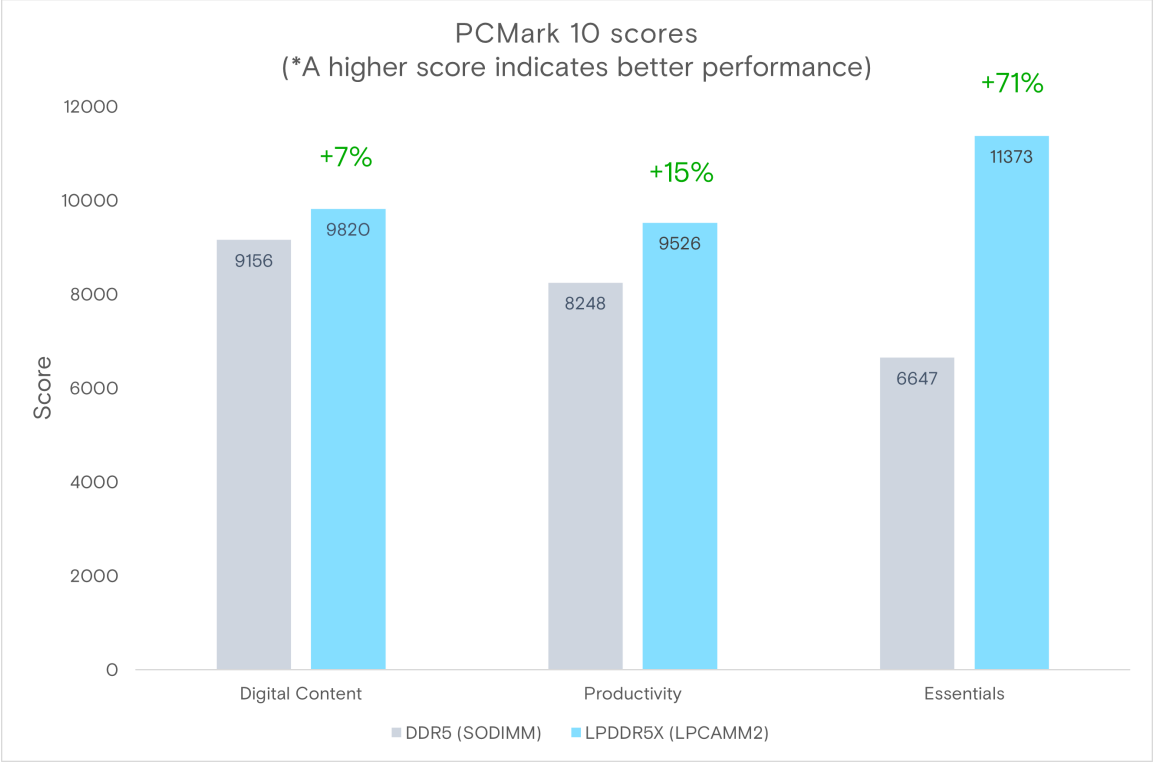

Figure 3: PCMark 10 performance scores

Digital Content	Productivity	Essentials
Tests performance for photo and video editing, and 3D content creation.	Measures PC performance for office applications such as spreadsheets and writing tools.	Models common activities that users perform many times a day such as web browsing and video conferencing.

Figure 4: PCMark 10 test groups

5. Based on lab estimates comparing dual-stacked SODIMMs at 5600 MT/s (16GB) with LPCAMM2 modules at 7500 MT/s (16GB). As a representation of commercially available systems with same-generation processors comparing DDR5 with LPDDR5X. Details of the benchmark estimated: PCMark 10 v2-1-2636.

The table below shows the forecasted speeds for both DDR5 and LPDDR5X. LPCAMM2 stays two speed grades ahead of SODIMMs for the next three years. Compared to SODIMMs, LPCAMM2's motherboard layout uses shorter traces (millimeters) from DRAM to the memory controller, which improves signal integrity, enabling users to achieve higher data rates.

	2024	2025	2026
LPDDR5X CAMM2	7500	8500	9600
DDR5 SODIMM	5600	6400	7200

Table 1: Forecasted DRAM memory speeds for DDR5 and LPDDR5X[6]

Power

Thin and light laptop designs require higher-speed memory along with lower power consumption and smaller form factors. LPCAMM2 meets these requirements as the industry's first modular form factor. LPDDR5X operates at faster data rates than DDR5 today with significantly lower power consumption.

As shown in the table below, LPDDR5X consumes 44-54% less power during active use and 86% less power during self refresh, leading to overall lower power consumption.

	State	DDR5-5600	LPDDR5X-6400	% Reduction
IDD x8 (mA)	I_{DD0} (active-precharge)	32	18	43.8%
	I_{DD2N} (idle)	23	7	69.6%
	I_{DD4R} (read)	302	140	53.6%
	I_{DD6} (self-refresh)	5.5	0.8	85.5%

Table 2: Measured current for DDR5 and LPDDR5X DRAM[7]

6. Speeds expected to be available in the majority of latest-generation systems shipping within each year listed in the table.
7. Empirical data based on Micron 1-beta nanometer DDR5 and LPDDR5X DRAM designs. Comparison of DDR5 x8 at 5600 MT/s (SODIMM) with LPDDR5X x8 at 6400 MT/s (LPCAMM2). Compares power per die measured in mA.

Below, we showcase power consumption based on three client benchmarks: AI-Benchmark, PCMark 10, and Cinebench™. The scores below highlight the power differences even in high-performance applications that require low latencies and high memory bandwidth. LPCAMM2 (LPDDR5X) uses less power across all benchmarks, achieving up to 61% lower power for AI-Benchmark.[4] LPDDR5X is lower power because the IDD currents are lower (see Table 2).

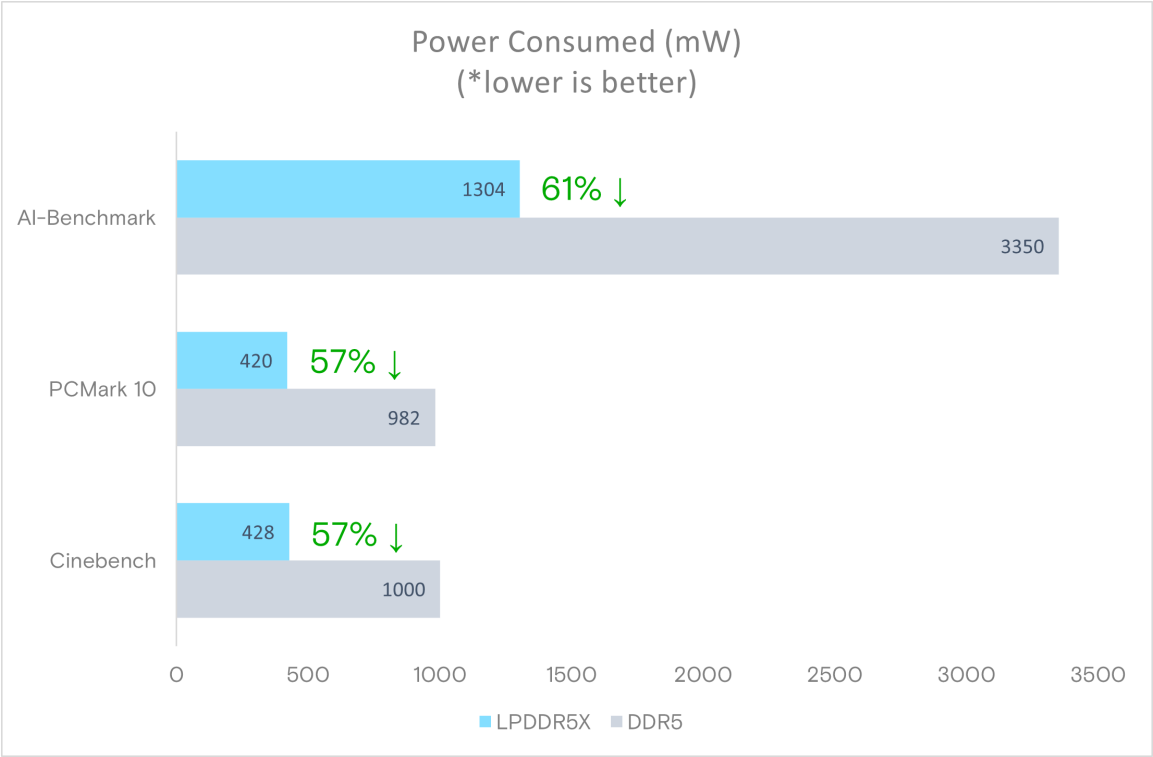

Figure 5: Benchmark power consumed

Conclusion

With increasing market demand for high-performance client laptops with long battery life, LPCAMM2 provides a comprehensive, smaller, lighter, modular solution for delivering speed at low power. Platform designers can configure LPCAMM2 with their preferred capacity and logical ranks using just one connector, further enabling customers to scale their client solutions.

4. Empirical data measured by Micron labs comparing DDR5 at 4800MTs to LPDDR5X at 4800MTs. Results show 57% lower power for both PCmark 10 and Cinebench and 61% lower power for AI-Benchmark.

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