GLOBAL TECHNOLOGY: SEMICONDUCTORS - MEMORY

Our take on CXMT's 4F² announcement and implication to Samsung Electronics and SK Hynix

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On October 10, news on Chinese DRAM maker CXMT's advancement in a new cell architecture called '4F²' was disclosed along with the positive comment by its president that the company plans to roll out a new server-memory product based on '4F²' architecture by the end of 2026.

Since then, the share price of major memory suppliers, including Samsung Electronics (SEC), SK Hynix (Hynix), Micron, SanDisk, Kioxia, and CXMT, fell by 11-26% taking away a total market value of well over US$700bn from the memory complex. We believe there were other reasons as well that likely contributed to the decline (e.g. credit and AI financing concerns, the higher-than-expected CPI, etc.), given CXMT's share price itself also saw a decline and NAND suppliers such as Kioxia/SanDisk (which are less relevant to this technology) also saw large declines. In addition, we also note that DRAM spot pricing, which typically acts as a sentiment indicator in the DRAM market, has continued to trend up throughout the same time period.

Nevertheless, in this report we examine the 4F² technology announced by CXMT and compare the technology/capacity between CXMT and SEC/Hynix in order to examine how much of this news has been potentially priced in. Bottom line, while we believe some concerns on the technology progress are appropriate and the capacity gap is narrowing, we believe there is still a significant technology gap, especially in advanced node DRAM and HBM.

The recent significant correction in the memory players' share prices could imply that the market may have underestimated both the capacity ramp-up and potential for technology breakthrough from China. We believe the former to be true; however, for the latter think the market may have actually overestimated, given our view of the considerable time it would take to complete customer qualifications and then achieve mass production at high yield levels, as well as narrow the gap in advanced DRAM technology such as HBM.

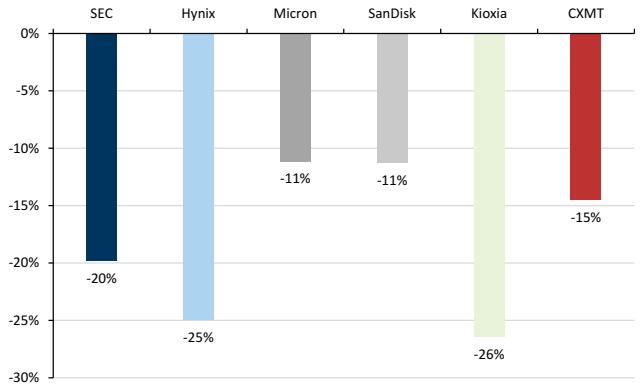
In addition, with now SEC trading at P/B valuation of 1.2X/0.9X and Hynix at 1.4X/0.9X for 2027E/2028E, we believe the stocks trading at below book value implies that the market is already pricing in a downcycle by 2028, which is much more pessimistic compared to our "higher for longer" view. Hence, we believe from the fundamental point of view the risk/reward at current valuations for SEC and

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Hynix are attractive, while also cognizant that there may be limited number of catalysts that could drive a quick recovery in the share prices for the names, at least in the near-term.

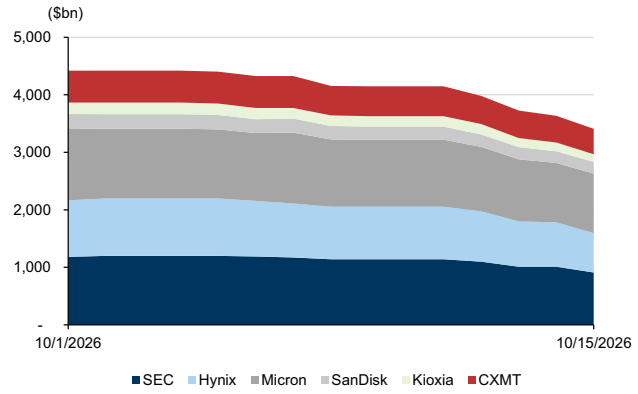
The author would like to thank Jiung Kang for his contribution to this report.

Exhibit 1: Share price of major memory suppliers fell by 11-26%
Share price decline of memory players



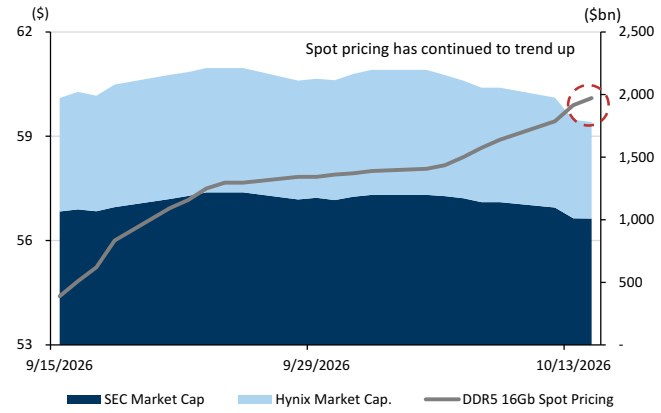
Source: Bloomberg, Goldman Sachs Global Investment Research

Exhibit 2: Total market value of of ~$738bn was taken away from the memory complex
Combined market cap. of memory players



Source: Bloomberg, Goldman Sachs Global Investment Research

Exhibit 3: Recent DRAM spot pricing has continued to trend up while share price declined
DDR5 spot pricing & SEC/Hynix market cap.



Source: Trendforce, Bloomberg, Goldman Sachs Global Investment Research

What is 4F² - the benefits and costs

DRAM is composed of millions of individual memory cells that store electrical charges to represent data signals. In conventional designs, DRAM relies on a $6F^2$ (3F×2F) layout (F represents the reference minimum feature size). By contrast, the $4F^2$ architecture optimizes cell geometry so that each single-bit memory cell occupies an area of just 2F×2F. Because this $4F^2$ layout requires less physical footprint per cell, manufacturers can pack more memory cells into the same die area, achieving higher bit density.

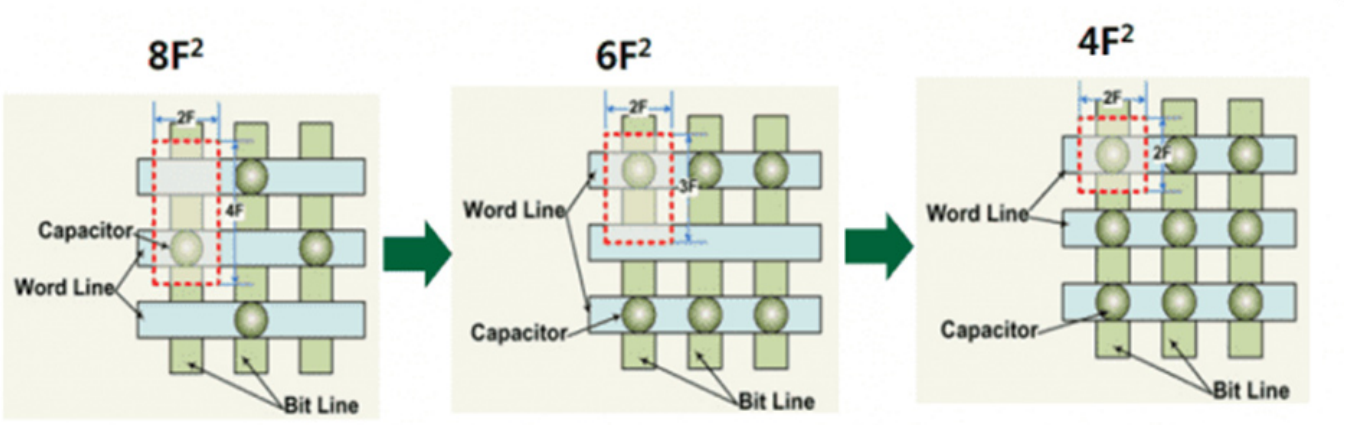
However, scaling down to $4F^2$ architecture introduces challenges, as smaller transistors become increasingly susceptible to current leakage from memory cells. To overcome these drawbacks, CXMT plans to integrate VSG (Vertical Surrounding Gate) transistors alongside W2W hybrid bonding. VSG design mitigates leakage by turning the current

path upright and fully wrapping a gate around it for better control. In tandem, hybrid bonding enables the memory cell and the control circuitry to be manufactured on separate wafers under individually optimized process conditions.

CXMT's move toward $4F^2$ can also be viewed as a response to China's constraints on conventional DRAM scaling. Restricted access to advanced lithography equipment, particularly EUV from ASML, makes it more challenging to reduce the minimum feature size, F. Moving from $6F^2$ to $4F^2$ offers another route to higher density: reducing the area required for each memory cell without relying entirely on finer lithography.

However, $4F^2$ does not only come with benefits. $4F^2$ architecture's smaller memory cells are more complex to manufacture, as vertical transistors must be built consistently, capacitors must still store enough charge in a smaller footprint, and closely packed wires should be precisely designed so that they don't interfere with one another. Hybrid bonding adds further processing steps and requires precise alignment between the memory and control-circuit layers. These challenges can increase manufacturing costs and reduce yields, potentially offsetting the benefit of fitting more memory into the same area.

Exhibit 4: Illustration of $4F^2$



Source: Company data, Goldman Sachs Global Investment Research

$4F^2$ progress/comments by each major player

However, CXMT is not the only player to prepare for next generation DRAM architecture. According to local news reports SEC is said to have successfully manufactured the world-first sub-10nm DRAM working die utilizing $4F^2$ architecture and VCT (Vertical Channel Transistor, similar to CXMT's VSG). SEC plans to finalize the development of $4F^2$ based 10a DRAM by end of 2026 and proceed on to customer qualification in 2027 and mass production by 2028, per these reports. These reports also indicated that SEC intends to leverage $4F^2$ architecture and VCT across consecutive process nodes - 10a, 10b, 10c - and transition to 3D DRAM from 10d. Concurrently, Hynix also said that it will incorporate $4F^2$ DRAM as part of its next-generation technology roadmap, as it will introduce its $4F^2$ vertical-gate platform at the 10nm level and below, using wafer bonding to place control circuitry beneath the memory cells. In July 2026, Hynix validated this approach by demonstrating successful read and write operations on a $4F^2$ test array.

How do we think about this potential technology advancement by CXMT?
While we acknowledge that CXMT's technological progress could negatively affect market sentiment, we believe it is still too early to assess the impact on the fundamentals of the leading DRAM players such as SEC and Hynix. A clearer assessment of this new technology would require considerably more information than what has been disclosed so far, including CXMT's current development stage (e.g., is it a R&D sample or a customer sample?), cost competitiveness (compared to already existing products in the market), expected yield rate, customer qualification timeline, and commercialization timeline.

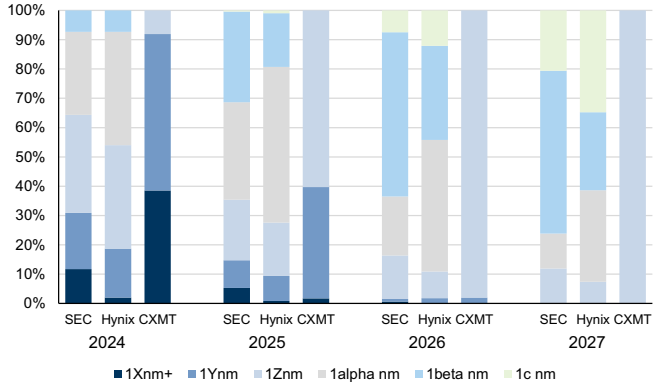
Based on the articles, CXMT would currently appear to be at the product design stage and is targeting the sampling stage by the end of 2026. While the technology itself could potentially be an achievement if the company is successful in meeting the target timeline, we still believe the company likely has significant ground to cover—particularly because customer qualification and mass production would present an entirely different levels of difficulty to achieve.

Furthermore, given the advanced roadmaps of SEC and Hynix, the core debate surrounding $4F^2$ is governed not by technical feasibility in the lab, but by whether the architecture can actually deliver manufacturing productivity and economic return. Leading players already possess alternative scaling methods —such as EUV lithography—which allow them to scale bit density and drive performance gains without prematurely going through yield loss and cost inflation associated with adopting $4F^2$ architecture. In contrast, CXMT's pivot toward $4F^2$ could also be more of a response to the export controls that otherwise restrict its access to advanced EUV equipment.

How does the DRAM node technology compare between SEC/Hynix vs. CXMT?
Despite CXMT's aggressive push for technological advancement, we still believe there is some gap between the technological level between Korean players and CXMT. As seen through Exhibit 5, while Korean player's manufacturing capacity is focused on 1b node with mix shifting towards 1c node, CXMT currently mostly produces 1z node DRAM and is likely to continue at this node for 2027. We believe that CXMT's further expansion into advanced nodes such as 1b and 1c could be difficult without access to EUV equipment. Global DRAM suppliers started to adopt EUV layers several years ago, with Hynix mainly starting from 1a nm and SEC even before 1a nm. While CXMT may make progress in DRAM scaling through alternative pathways that do not need to utilize EUV, we believe there would still be technological limitations and cost implications in doing so.

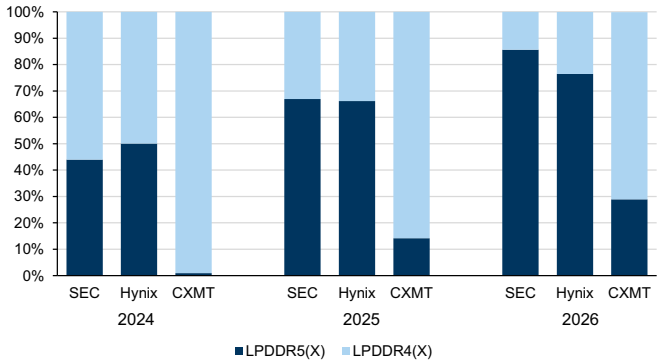
Exhibit 5: Korean player's manufacturing capacity is shifting towards 1c node, while CXMT mostly produces 1z node DRAM

SEC, Hynix, CXMT DRAM node comparison



Source: Trendforce, Company data, Goldman Sachs Global Investment Research

Exhibit 6: SEC, Hynix, CXMT LPDDR generation comparison



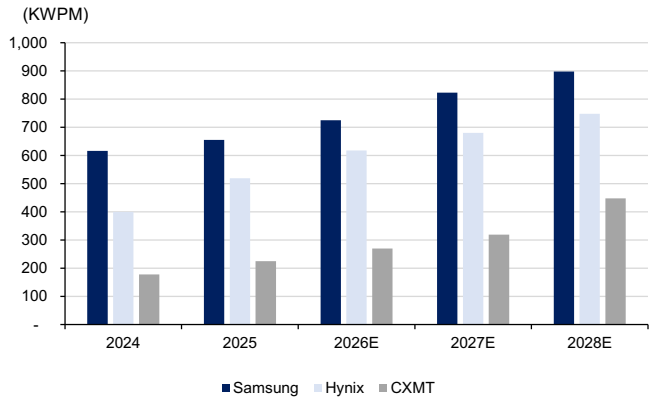
Source: Trendforce, Company data, Goldman Sachs Global Investment Research

How does DRAM capacity compare between SEC/Hynix vs. CXMT?

As for 2026, we expect SEC and Hynix's DRAM wafer capacity to reach 770KWPM and 660KWPM by year-end, while we estimate CXMT to achieve 290KWPM over the same period. However, we expect CXMT to rapidly ramp up its capacity to 513KWPM by end of 2028, increasing its capacity by 77% in two years. Compared to CXMT's aggressive ramp-up, SEC and Hynix's capacity additions that we expect are relatively modest, as we estimate SEC and Hynix to reach 930KWPM and 770KWPM by end of 2028, implying 21% and 17% increases, respectively. By 2028, we still expect the Korean memory makers to be the leading players in terms of capacity by a considerable amount; however, we do recognize CXMT's agile initiatives to scale up its production volume and close the gap with the leading players.

Exhibit 7: Compared to CXMT's aggressive ramp-up, SEC and Hynix's capacity additions that we expect are relatively modest

SEC, Hynix, CXMT DRAM capacity trend



Source: Company data, Goldman Sachs Global Investment Research

Will CXMT catch up with Korean player's HBM leadership?

We expect larger hurdles for CXMT in narrowing the gap in HBM relative to the leading players. HBM competitiveness depends not only on DRAM technology itself, but also on

the packaging technology and the ability to manufacture advanced base dies that sit underneath the memory stack. In earlier generations like HBM3, base dies could still be produced on mature nodes. However, as HBM advances toward next-generation specifications, the base die has shifted to advanced foundry nodes (e.g. 4nm foundry for SEC's HBM4 base die) to handle much higher bandwidth and power efficiency. For CXMT to build a competitive next-generation HBM product, local Chinese foundries would also need to produce advanced-node base dies at scale. Yet, due to ongoing geopolitical export controls that restrict domestic foundries from acquiring advanced WFE—notably EUV lithography tools—securing base dies based on advanced nodes locally could potentially remain a bottleneck in catching up to the leading suppliers of HBM.

Despite CXMT's aggressive capacity ramp, likely not enough to satisfy local China demand

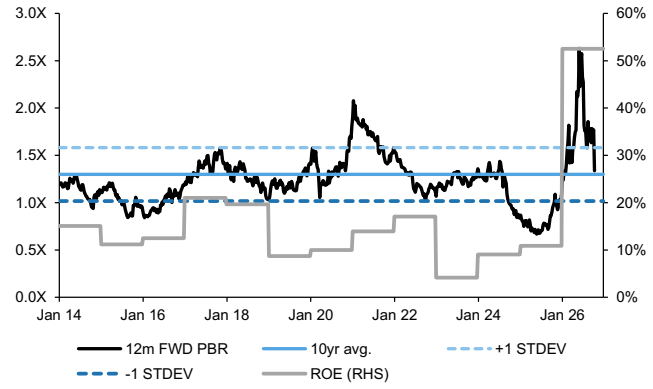
The recent sell-off in memory stocks following CXMT's $4F^2$ announcement suggests the market may have underestimated China's catch-up ambitions, raising concerns over long-term memory pricing if incremental supply comes online from China. However, despite the aggressive capacity ramp assumptions and bit supply growth assumptions for CXMT over the coming years, we expect the company to cover only 50% of China's domestic DRAM demand and 40% of its domestic HBM demand by 2028. As a result, a large portion of the rapidly expanding China DRAM demand will most likely continue to rely on the leading memory suppliers. And, we believe despite rising competition from CXMT, both SEC and Hynix will continue to have significant opportunities in the China market.

What is priced in?

The recent significant correction in the memory players' share price could imply that the market may have underestimated both the capacity ramp-up and potential for technology breakthroughs from China. We believe the former to be true; however, for the latter believe the market may have actually overestimated, given our view of the considerable time it would take to complete customer qualifications and then achieve mass production at high yield levels, as well as narrow the gap in advanced DRAM technology such as HBM between CXMT and the leading players. With now SEC trading at P/B valuation of 1.2X/0.9X and Hynix at 1.4X/0.9X for 2027E/2028E, we believe the stocks trading at below book value implies that the market is already pricing in a downcycle by 2028, which is much more pessimistic compared to our "higher for longer" view. Hence, we believe from the fundamental point of view the risk/reward at current valuations for SEC and Hynix are attractive, while also cognizant that there may be limited number of catalysts that could drive a quick recovery in the share price for the names, at least in the near-term.

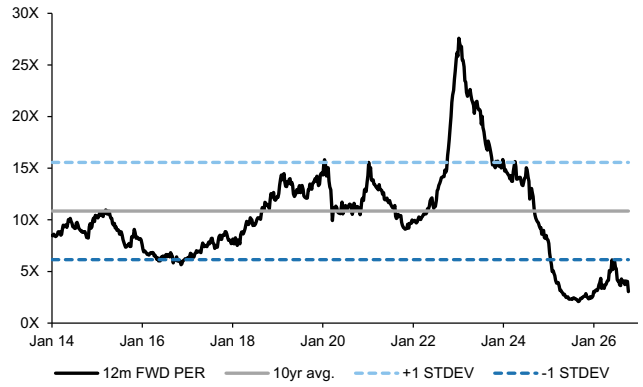


Exhibit 8: SEC shares are trading at 1.3X 12m FWD P/B with a 2026E/2027E ROE of 53%/54%
SEC 12m FWD P/B vs. ROE



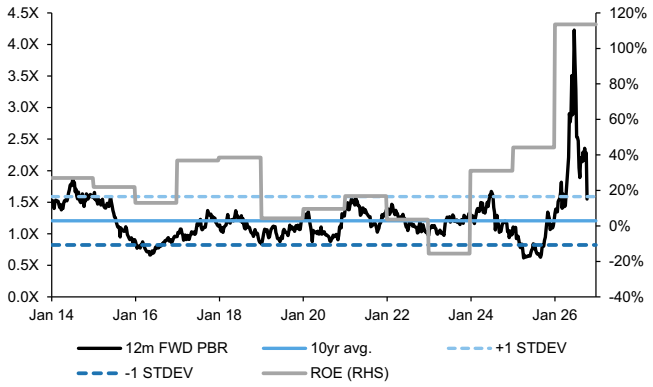
Source: Bloomberg, Company data, Goldman Sachs Global Investment Research

Exhibit 9: SEC shares are currently trading at 3.0X 12m FWD P/E
SEC 12m FWD P/E



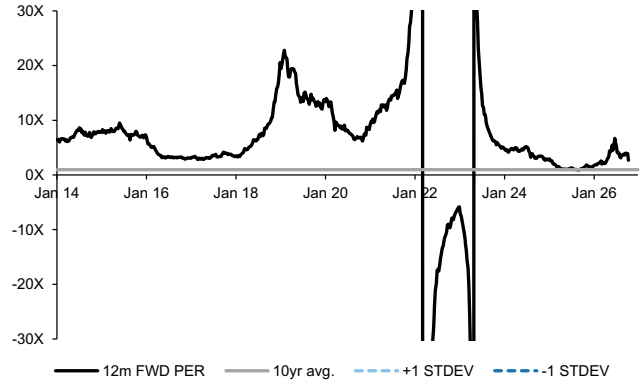
Source: Bloomberg, Company data, Goldman Sachs Global Investment Research

Exhibit 10: Hynix shares are trading at 1.5X 12m FWD P/B with 2026E/2027E ROE of 114%/68%
Hynix 12m FWD P/B



Source: Company data, Goldman Sachs Global Investment Research, Bloomberg

Exhibit 11: Hynix shares are trading at 2.7X 12m FWD P/E



Source: Company data, Goldman Sachs Global Investment Research, Bloomberg

Price Target Risks and Methodology - Samsung Electronics
Valuation methodology: Our 12m 2026-2027E EV/EBITDA-based SOTP target price for the common share is W500,000. Our 12-month target price for the preference share is W380,000, applying an updated pref-to-common discount of 24%, derived from average between 1) the pref discount of the 2-factor model, and 2) the 1-year historical average discount to common shares. We are Buy rated on both the common and preference shares.

Key downside risks: 1) major deterioration in memory supply/demand, 2) sharp contraction in smartphone margins, and 3) mobile OLED market share loss.

Price Target Risks and Methodology - SK Hynix Inc.
Valuation methodology: Our 2026E/27E avg. P/E-based 12m TP is W3,500,000, applying a target P/E multiple of 9.0X.

Key risks: Key risks include 1) major deterioration in memory supply/demand and delay

in technology migration, 2) weaker demand for smartphones/PCs/servers which would impact overall conventional memory demand, 3) Samsung's positive HBM business progress which would impact HBM revenue and profit, 4) lower AI-related capex which would impact overall HBM demand, and thus HBM revenue/profit for the company.

Valuation: Our 12-month target price of Rmb129 is based on a 16.6x 2030E P/E, discounted back to 2027E at a COE of 12.7%. Our target multiple is derived from peers' correlation between forward-year trading P/E and earnings growth.

Key downside risks: Fiercer-than-expected market competition; Weaker-than-expected market demand; Unstable geopolitical situation.

Disclosure Appendix

Reg AC

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Growth is based on a stock's forward-looking sales growth, EBITDA growth and EPS growth (for financial stocks, only EPS and sales growth), with a higher percentile indicating a higher growth company. **Financial Returns** is based on a stock's forward-looking ROE, ROCE and CROCI (for financial stocks, only ROE), with a higher percentile indicating a company with higher financial returns. **Multiple** is based on a stock's forward-looking P/E, P/B, price/dividend (P/D), EV/EBITDA, EV/FCF and EV/Debt Adjusted Cash Flow (DACF) (for financial stocks, only P/E, P/B and P/D), with a higher percentile indicating a stock trading at a higher multiple. The **Integrated** percentile is calculated as the average of the Growth percentile, Financial Returns percentile and (100% - Multiple percentile).

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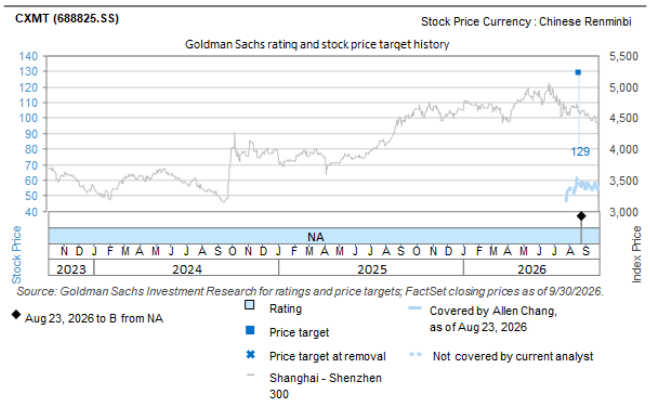
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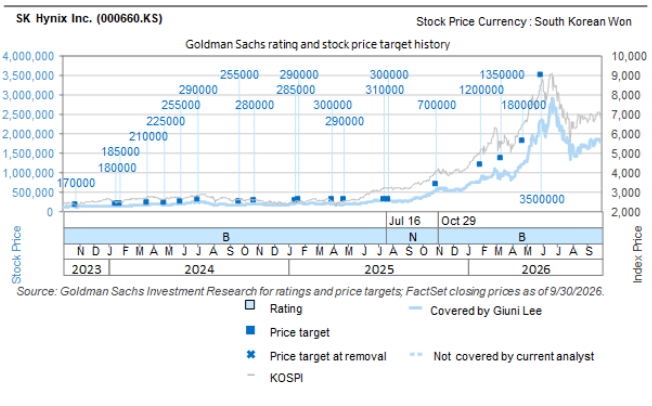
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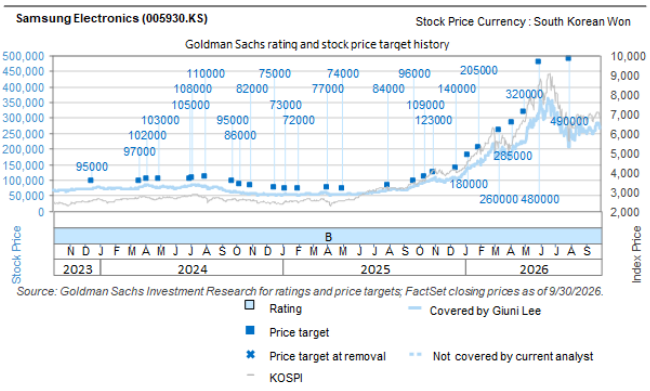
Price target and rating history chart(s)



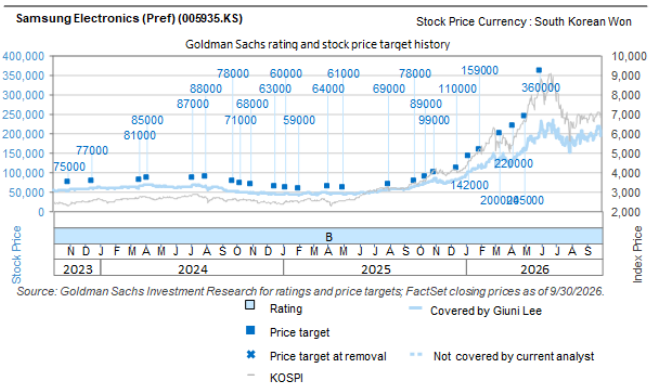
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Target price history table(s)

Samsung Electronics (Pref) (005935.KS)

Date of report	Target price (W)	Closing price (W)
08-Oct-26	380,000	194,000
31-May-26	360,000	202,500
30-Apr-26	245,000	158,300
07-Apr-26	220,000	130,900

CXMT (688825.SS)

Date of report	Target price (Rmb)	Closing price (Rmb)
23-Aug-26	129.00	58.00

Samsung Electronics (Pref) (005935.KS)

Date of report	Target price (W)	Closing price (W)
11-Mar-26	200,000	138,900
29-Jan-26	159,000	115,600
08-Jan-26	142,000	101,900
16-Dec-25	110,000	79,800
30-Oct-25	99,000	82,500
14-Oct-25	89,000	72,300
22-Sep-25	78,000	66,700
31-Jul-25	69,000	57,600
01-May-25	61,000	46,850
01-Apr-25	64,000	47,700
02-Feb-25	59,000	43,000
08-Jan-25	60,000	46,800
16-Dec-24	63,000	46,550
31-Oct-24	68,000	47,950
08-Oct-24	71,000	49,900
23-Sep-24	78,000	52,400
31-Jul-24	88,000	64,900
05-Jul-24	87,000	68,000
05-Apr-24	85,000	69,000
21-Mar-24	81,000	65,800
17-Dec-23	77,000	59,300
31-Oct-23	75,000	53,600

CXMT (688825.SS)

Date of report	Target price (Rmb)	Closing price (Rmb)

Samsung Electronics (005930.KS)

Date of report	Target price (W)	Closing price (W)
08-Oct-26	500,000	262,000
30-Jul-26	490,000	207,000
31-May-26	480,000	317,000
30-Apr-26	320,000	220,500
07-Apr-26	285,000	196,500
11-Mar-26	260,000	190,000
29-Jan-26	205,000	160,700
08-Jan-26	180,000	138,800
16-Dec-25	140,000	102,800
30-Oct-25	123,000	104,100
14-Oct-25	109,000	91,600
22-Sep-25	96,000	83,500
31-Jul-25	84,000	71,400
01-May-25	74,000	55,500
01-Apr-25	77,000	58,800
02-Feb-25	72,000	52,400
08-Jan-25	73,000	57,300
16-Dec-24	75,000	55,600
31-Oct-24	82,000	59,200
08-Oct-24	86,000	60,300
23-Sep-24	95,000	62,600
31-Jul-24	110,000	83,900
05-Jul-24	108,000	87,100
01-Jul-24	105,000	81,800
30-Apr-24	103,000	77,500
05-Apr-24	102,000	84,500
21-Mar-24	97,000	79,300
17-Dec-23	95,000	73,300

SK Hynix Inc. (000660.KS)

Date of report	Target price (W)	Closing price (W)
31-May-26	3,500,000	2,333,000
23-Apr-26	1,800,000	1,225,000
11-Mar-26	1,350,000	955,000
28-Jan-26	1,200,000	841,000
29-Oct-25	700,000	558,000
24-Jul-25	300,000	269,500
16-Jul-25	310,000	296,000
24-Apr-25	290,000	178,300
01-Apr-25	300,000	197,000
23-Jan-25	290,000	219,500
15-Jan-25	285,000	198,200
24-Oct-24	280,000	198,200
23-Sep-24	255,000	162,000
01-Jul-24	290,000	235,500
27-May-24	255,000	201,500
25-Apr-24	225,000	170,600
21-Mar-24	210,000	170,000
25-Jan-24	185,000	137,400
17-Jan-24	180,000	131,000
26-Oct-23	170,000	120,000

Price targets shown in table(s) are unadjusted for corporate actions.



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