

Greater China Technology

ABF market update: Hot Chips 34 key takeaways; content enrichment to drive supply tightness

According to our recent supply chain checks and the 2022 Hot Chips 34 event ([here](#)), Intel/AMD/Nvidia (covered by Toshiya Hari) will continue to launch more advanced packaged IC for their high-performance products in the coming quarters/years, which will drive the overall ABF substrate market demand in the long term, given the still low penetration rate of advanced packaging IC now ([Exhibit 1](#)). Intel's CEO Pat Gelsinger in the keynote speech of Hot Chips 34 mentioned the company will focus on 2.5D/3D packaging technology (EMIB, Foveros etc technologies) to strengthen its chip performance, which we believe should lead to larger IC size and more complex ABF substrate design. AMD already has its MCM packaged CPU and server GPU/accelerator, and will launch its first PC GPU that adopts 2.5D packaging technology later this year, and Nvidia will launch its first 2.5D packaged server GPU in 1H23, which all suggests a strong 2.5D/3D packaging technology upgrade trend should accelerate in the coming years. We provide a recent update for key CPU/GPU etc ICs below and expect the packaging technology upgrade trend will continue to drive overall ABF products' spec and suggest long-lasting ABF supply tightness.

James Wang
+886(2)2730-4191 |
james.p.wang@gs.com
Goldman Sachs (Asia) L.L.C., Taipei
Branch

Allen Chang
+852-2978-2930 | allen.k.chang@gs.com
Goldman Sachs (Asia) L.L.C.

Daiki Takayama
+81(3)6437-9870 |
daiki.takayama@gs.com
Goldman Sachs Japan Co., Ltd.

Chao Wang
+886(2)2730-4195 | kuan-
chao.wang@gs.com
Goldman Sachs (Asia) L.L.C., Taipei
Branch

Goldman Sachs does and seeks to do business with companies covered in its research reports. As a result, investors should be aware that the firm may have a conflict of interest that could affect the objectivity of this report. Investors should consider this report as only a single factor in making their investment decision. For Reg AC certification and other important disclosures, see the Disclosure Appendix, or go to www.gs.com/research/hedge.html. Analysts employed by non-US affiliates are not registered/qualified as research analysts with FINRA in the U.S.

Exhibit 1: Advanced packaging ABF demand overview (assuming no ABF capacity constraints)

	2020	2021	2022E	2023E	2024E	2025E
Server CPU 2.5D/3D packaging adoption rate	6%	10%	15%	52%	84%	100%
DT CPU 2.5D/3D packaging adoption rate	18%	18%	19%	21%	37%	84%
GPU/FPGA/ASIC AI accelerator 2.5D/3D packaging adoption rate	1%	1%	5%	20%	40%	60%
Networking (FPGA/ASIC) 2.5D/3D packaging adoption rate	35%	46%	54%	55%	56%	56%
Others IC 2.5D/3D packaging adoption rate	1%	1%	5%	20%	37%	56%
As % of total logic IC shipment	16%	18%	21%	30%	46%	75%
Average die per 2.5D/3D IC	2.5	2.5	3.0	3.0	3.5	3.5
2.5D/3D designed IC ABF consumption as % of total ABF consumption	38%	41%	47%	58%	72%	91%
Total ABF demand (US\$bn) assuming no supply constraints	5.0	7.4	10.0	13.5	18.3	25.1
Total 2.5D/3D IC ABF demand (US\$bn) assuming no supply constraints	1.9	3.0	4.7	7.8	13.2	22.9
YoY		61%	55%	67%	70%	73%

Source: Company data, Goldman Sachs Global Investment Research

Key PC CPU/GPUs update: Intel Meteor Lake PC CPU

Intel announced at the Hot Chips 34 event that it will launch and ship the Meteor Lake CPU in 2023 (we only expect very small volume shipment in 2H23), which will be the first Intel client CPU packaged by the advanced packaging technology (which is a 3D Foveros packaged IC; Intel 4 CPU tile + TSMC 5nm GFX tile+ TSMC 6nm SoC tile and IOE tile) with 50%+ more ABF capacity consumption (including yield rate loss) compared to Alder Lake/Raptor Lake generation, and should suggest strong PC ABF demand (45% of the total ABF substrates market demand in 2022E; Exhibit 16) growth in coming years. Moreover, Intel also announced plans to launch its new Arrow Lake products in 2024, which are also based on 3D packaging technology, and suggest a strong ABF substrates demand growth rate in the long term.

AMD Raphael (Ryzen 7000 series) PC CPU

The Raphael PC CPU's component suppliers have already started mass production (CPU socket/ ABF substrates) in August, and the IC will come to the market in the coming months this year, which consumes 20%+ more ABF substrate area per IC compared to the past generation products (from 8-10 layers in the previous generation to 10-12 layers) with even higher ABF capacity consumption, considering the yield rate loss for producing higher layer count products.

AMD RDNA3 PC GPU

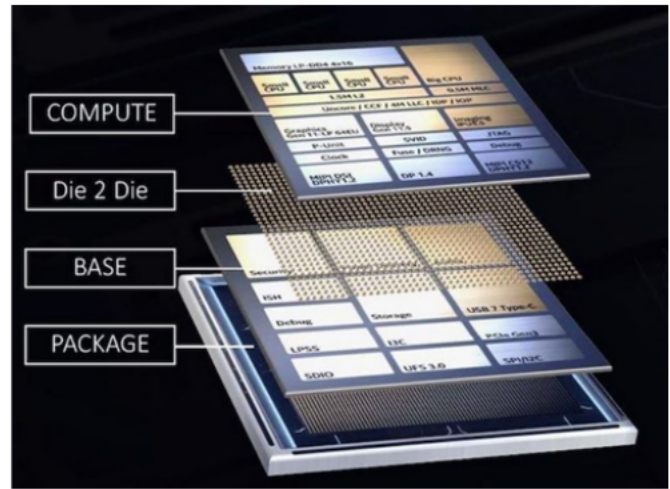
We believe AMD will launch its new RDNA3 PC GPU in the coming months, which will be the first PC GPU to adopt 2.5D packaging technology, with 80%+ more ABF capacity consumption compared to the previous generation, which should also benefit ABF suppliers.

Exhibit 2: Comparison between 3 different packaging designs performance

Company	Intel	AMD	TSMC
Chip	Stratix 10	Zen	N.A
Technology	EMIB	MCM	CoWoS
Channel	1mm	N/A	500 um
Chiplet I/O bumps pitch	55um	150 um	40 um
Interconnect	AIB	IF	LIPINCON
Data Rate	2 GT/s	10.6GT/s	8 GT/s
Power consumption	1.2pJ/bit	2pJ/bit	0.56 pJ/bit

Source: Company data

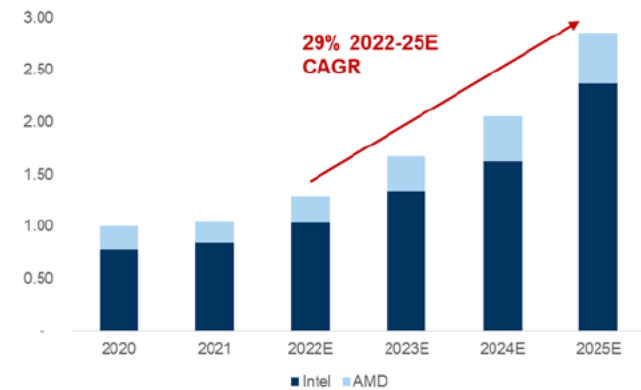
Exhibit 3: Intel Foveros packaging design



Source: Company data

Exhibit 4: We believe overall PC CPU ABF content per IC will grow by a 29% 2022-25E CAGR

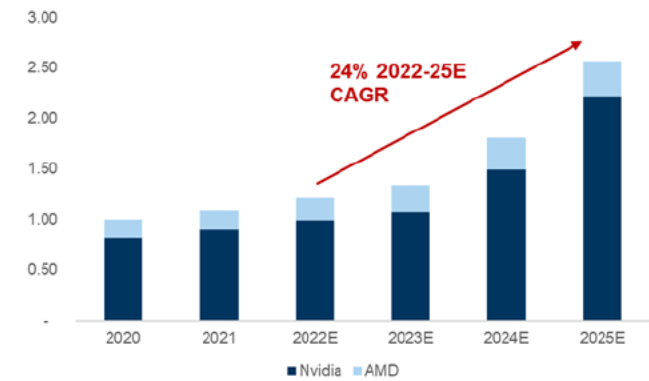
Rebased ABF content per IC in 2020 as 1



Source: Company data, Goldman Sachs Global Investment Research

Exhibit 5: We believe overall PC GPU ABF content per IC will grow by a 24% 2022-25E CAGR

Rebased ABF content per IC in 2020 as 1



Source: Company data, Goldman Sachs Global Investment Research

**Key server CPU/GPUs update:
AMD Genoa server CPU**

According to our supply chain check, AMD Genoa will launch in 1H23, which is based on chiplet packaging technology, with 50%+ more ABF capacity consumption compared to the Milan generation product (both ABF packaging size and layer count are higher than Milan), which should drive the overall ABF substrates demand in 2023/24E, and suggest better ASP for ABF substrates suppliers.

Intel Eagle Stream server CPU

Intel Eagle Stream should start mass production from 1H23 with small volume production starting from 2H22, according to our supply chain check. For the ABF capacity consumption, given the slightly larger packaging size and higher layer count compared to the old Whitley product, the ABF consumption is 50%+ higher than Whitley (given the Eagle Stream is the first EMIB packaged Intel server IC). We

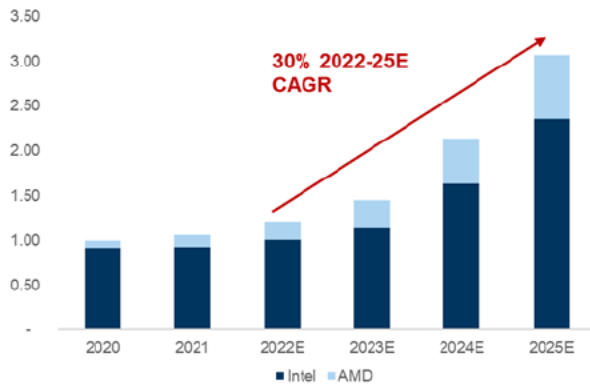
therefore believe the Intel server ABF substrates players should benefit from the strong demand growth in 2023/24E.

Nvidia Hopper server GPU

Nvidia will launch the new Hopper server GPU in 1H23, which is the company’s first 2.5D packaging server GPU (2 dies packaged in one IC) with 100%+ ABF consumption given the larger packaging size and higher layer count, which should be the key driver for the ABF suppliers in coming years. However, Nvidia’s overall order demand will likely be weak in 4Q22 given it still holds high inventory on hand (see [here](#); Kinsus and NYPCB already saw Nvidia cut 4Q22 orders), and it might want to digest more inventory before launching the new GPU platform in 1H23.

Exhibit 6: Server CPU ABF content per IC to grow by a 30% 2022-25E CAGR

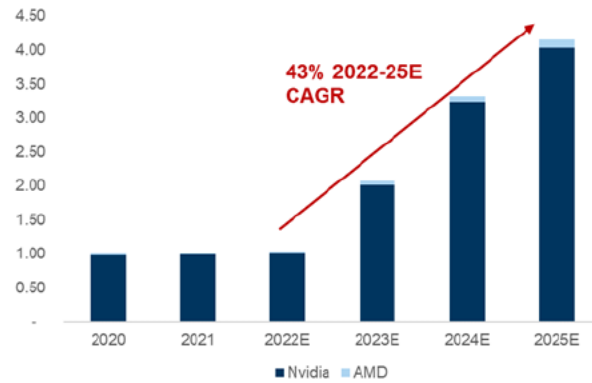
Rebased ABF content per IC in 2020 as 1



Source: Company data, Goldman Sachs Global Investment Research

Exhibit 7: We believe the server GPU ABF content per IC will grow significantly in coming years with more chiplet designed products launched

Rebased ABF content per IC in 2020 as 1



Source: Company data, Goldman Sachs Global Investment Research

Exhibit 8: PC/server CPU roadmap

Application	Brand	Technology node	Codename (Series) [Platform]	Launch quarter	Package (pin-count)	Package size (mm)	Package dimension (mm ²)	ASP (US\$)
Desktop CPU	Intel	32nm	Sandy Bridge	1Q11	LGA1155	37.5*37.5	1,406	up to 999
		22nm	Ivy Bridge	2Q12	FCLGA1155	37.5*37.5	1,406	up to 999
		22nm	Haswell	2Q13	FCLGA1150	37.5*37.5	1,406	up to 999
		14nm	Broadwell (C)	1Q15	FCLGA1150	37.5*37.5	1,406	up to 366
		14nm	Broadwell (R)	1Q15	FCBGA1364	37.5*37.5	1,406	up to 1723
		14nm	SkyLake	3Q15	FCLGA1151	37.5*37.5	1,406	up to 389
		14nm	SkyLake (X)	2Q17	FCLGA2066	52.5*45.0	2,363	up to 1900
		14nm+	Kaby Lake	1Q17	FCLGA1151	37.5*37.5	1,406	up to 350
		14nm++	Coffee Lake	4Q17	FCLGA1151	37.5*37.5	1,406	up to 1979
		14nm++	Cascade Lake (E9 X)	4Q19	FCLGA2066	52.5*45.0	2,363	up to 999
		14nm+++	Comet Lake	2Q20	FCLGA1200	37.5*37.5	1,406	up to 488
		14nm++++	Rocket Lake	4Q20	FCLGA1200	37.5*37.5	1,406	up to 599
		Intel 7 (previous Intel 10nm+++)	Alder Lake	4Q21	FCLGA1700	45.0*37.5	1,688	up to 589
		Intel 7 (previous Intel 10nm++++)	Raptor Lake	2H22F	FCLGA1700	45.0*37.5	1,688	TBA
	Intel 4 (previous Intel 7nm) & External N5	Meteor Lake	2H23/2024F	FCLGA1851	45.0*37.5	1,688	TBA	
	Intel 20A (previous Intel 5nm) & External N3	Arrow Lake	2024F	FCLGA1851	45.0*37.5	1,688	TBA	
	Intel 18A (previous Intel 3nm)	Lunar Lake	2025F	TBA	TBA	TBA	TBA	
	AMD	14nm	Summit Ridge	1Q17	µOPGA-1331	40.0*40.0	1,600	up to 499
		14nm	Summit Ridge (TR)	3Q17	FCLGA-4904	58.5*75.4	4,411	N/A
		12nm	Pinnsade Ridge	2Q18	µOPGA-1331	40.0*40.0	1,600	up to 3990
7nm		Matisse	3Q19	µOPGA-1331	40.0*40.0	1,600	up to 3990	
7nm+		Vermeer	4Q20	µOPGA-1331	40.0*40.0	1,600	up to 999	
5nm		Raphael	2H22F	µOPGA-1718	40.0*40.0	1,600	TBA	
3nm	Granite Ridge	2023/24F	µOPGA-1718	TBA	TBA	TBA		
Server CPU	Intel	32nm	Sandy Bridge (Romley)	2Q11	LGA 1155	37.5*37.5	1,406	up to 3616
		22nm	Ivy Bridge (Xeon E3) (Romley)	2Q12	FCLGA 1155	37.5*37.5	1,406	up to 885
		22nm	Ivy Bridge (Xeon E7) (Romley)	1Q14	FCLGA 2011	52.0*45.0	2,430	up to 6841
		22nm	Haswell (Grantley)	2Q13	FCLGA 1150	37.5*37.5	1,406	up to 7174
		14nm	Broadwell (Pentium D) (Grantley)	1Q15	FCBGA 1067	37.5*37.5	1,406	up to 200
		14nm	Broadwell (Xeon E3) (Grantley)	2Q15	FCLGA 1150	37.5*37.5	1,406	up to 556
		14nm	Broadwell (Xeon E5, E7) (Grantley)	1Q16	FCLGA 2011	45.0*52.5	2,363	up to 4115
		14nm+	SkyLake (Purley)	4Q15	FCLGA 1151	37.5*37.5	1,406	up to 3115
		14nm+	SkyLake (High performance) (Purley)	3Q17	FCLGA 3647	76.0*56.5	4,294	up to 13001
		14nm++	Cascade Lake (High performance) (Purley)	2Q19	FCLGA 3647	76.0*56.5	4,294	up to 17906
		14nm+++	Cooper Lake (Cedar Island)	2Q20	FCLGA 4189	77.5*56.5	4,379	up to 13012
		10nm+	Ice Lake (Whitley)	1Q21	FCLGA 4189	77.5*56.5	4,379	up to 8099
		Intel 7 (previous Intel 10nm+++)	Sapphire Rapids (Eagle Stream)	1H23F	FCLGA 4677	XCC version: 78.0*57.0 HBM version: 100.0*57.0	XCC version: 4446 HBM version: 5700	TBA
		Intel 7 (previous Intel 10nm+++)	Emerald Rapids (Eagle Stream)	2H23F	FCLGA 4677	80.0*59.0 (TBA)	4720 (TBA)	TBA
Intel 3 (previous Intel 7nm+)	Granite Rapids (Mountain Stream P-core)	2024F	FCLGA 4677	82.0*61.0 (TBA)	5002 (TBA)	TBA		
Intel 3 (previous Intel 7nm+)	Sierra Forest (Mountain Stream E-core)	2024F	FCLGA 4677	82.0*61.0 (TBA)	5002 (TBA)	TBA		
AMD	14nm	EPYC Naples	2Q17	FCLGA4094	58.5*75.4	4,411	up to 4200	
	7nm	EPYC Rome	3Q19	FCLGA4094	58.5*75.4	4,411	up to 6590	
	7nm+	EPYC Milan	1Q21	FCLGA4094	58.5*75.4	4,411	up to 7890	
	7nm+	EPYC Milan X	1Q22	FCLGA4094	58.5*75.4	4,411	up to 8800	
	5nm	EPYC Genoa	1H23F	FCLGA6096	72.0*75.4	5,429	TBA	
	5nm	EPYC Bergamo	2H23F	FCLGA6096	72.0*75.4	5,429	TBA	
	3nm	EPYC Turin	2024/25F	FCLGA6096	TBA	TBA	TBA	

Source: Company data, Goldman Sachs Global Investment Research

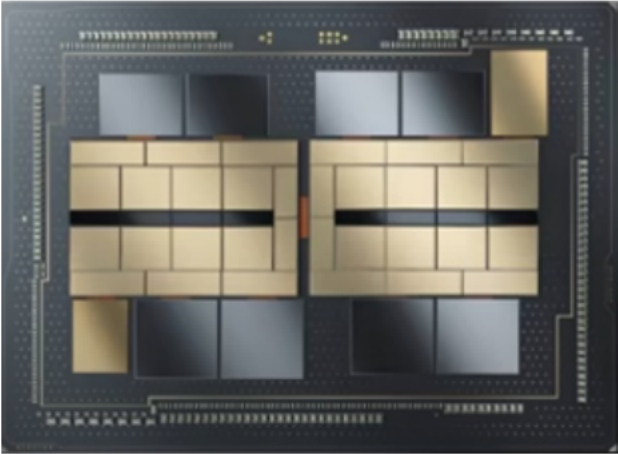
Other ICs update

Intel's server GPU Ponte Vecchio and Nvidia's new Grace server CPU (launch in 1H23 together with Hopper server GPU) will both adopt the advanced packaging technology, which should continue to suggest a higher advanced packaging IC penetration rate; however, we don't expect the volume demand for both products to be significant in 2023, and should only suggest limited upside for the overall ABF substrates industry given the small volume.

On the other hand, Tesla announced the details of its DOJO super computer system micro-architecture at Hot Chips 34. The Dojo AI system is for the company AI training for self-driving system, which is built by the company's owned D1 die (die-size 645mm²). The company packages 25 D1 computing dies (5*5 D1) and 40 I/O dies in one Dojo training tile package by heterogeneous RDL, with liquid cooling and mechanical packaging inside the tile, and the tiles are scalable with their own interconnected technology.

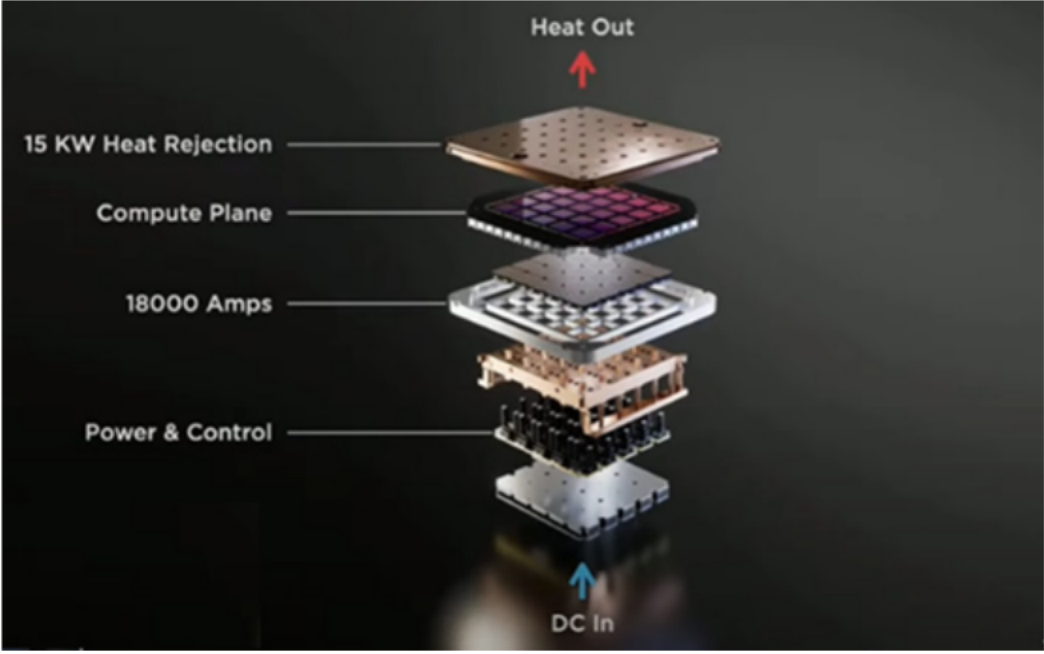
Other ICs mentioned at Hot Chips 34 included China vendor Biren's BR100 GPGPU (die size at 1,074mm² vs. Nvidia's Ampere of 826mm²), which suggests the strong packaging technology upgrade trend will accelerate not only in the US semi industry but also in the China semi market, and benefit ABF players who have capacity in China.

Exhibit 9: Intel Ponte Vecchio GPU diagram - EMIB + Foveros



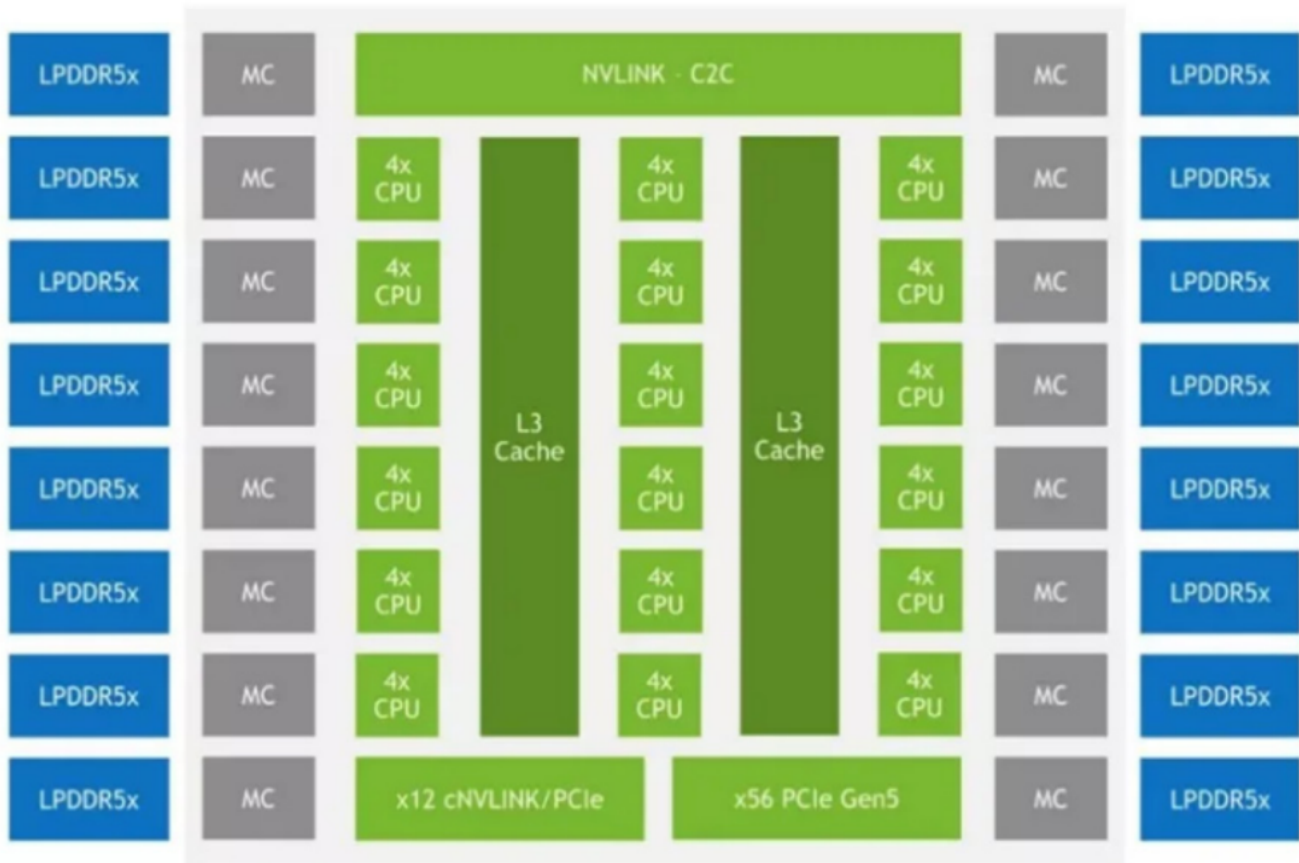
Source: Company data

Exhibit 10: Tesla Dojo Training Tile design



Source: Company data

Exhibit 11: Nvidia Grace CPU design diagram - a chiplet designed ARM based CPU



Source: Company data

Our thoughts

We believe the IC suppliers’ positive attitude on adopting advanced packaging technology in their high-performance IC in coming years should continue to drive the packaging size of new ICs and suggest more complex ABF substrates design, just as we mentioned in our early 2022 ABF industry report ([here](#)). We believe the growing packaging size and more complex ABF substrates design will continue to drive the overall ABF substrates market demand, and is irreversible. As such, we believe the long-term ABF market size will continue to grow ([Exhibit 13](#)) with the increasing 2.5D/3D packaging penetration rate ([Exhibit 1](#)) which should lead to a higher ABF substrates layer count and larger packaging size for ICs. Also, the potentially lower yield rate given more high-layer count product launches could make the ABF substrates capacity consumption growth rate even higher, and lead to tighter supply demand conditions.

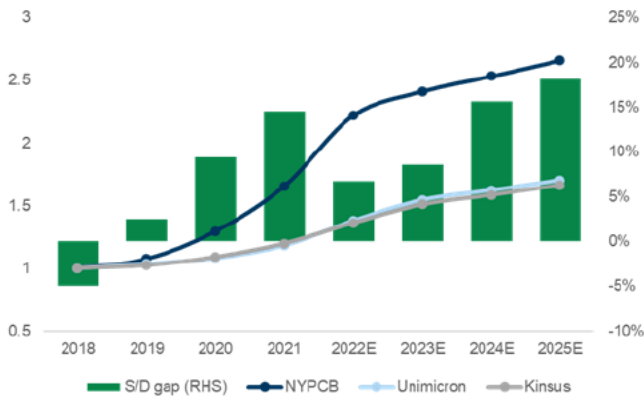
For ABF ASP, we continue to believe the spec upgrade given the increasing penetration rate of advanced packaging IC will drive better ABF ASP in the long term, as the IC packaging technology upgrade seems to be the key focus for IC suppliers in the coming years (players mainly focused on semi front-end process upgrade before 2019). We believe ABF suppliers can still enjoy a favorable ASP trend ([Exhibit 12](#)) given spec upgrade even excluding the like-for-like base pricing hike after 2023 (NYPCB and Kinsus

believe the like-for-like base ABF substrate pricing hike will be less frequent after 2023, given the already high base in 2022).

Overall, we maintain our positive view on ABF substrates suppliers in the coming years, given the upgrading spec, which should not only drive ABF suppliers' product ASP, but also suggest favorable ABF substrates demand growth, given the higher ABF capacity consumption. However, the recent semi industry demand slowdown given ongoing inventory digestion (TSMC believes the inventory digestion should last for few quarters - [here](#)) suggests near-term ABF substrates demand volatility, which could more or less impact on substrates players' revenue/GM growth rate in 2H22, but we expect the demand to come back rapidly in 2023. Maintain Buy on NYPCB/Kinsus/Unimicron.

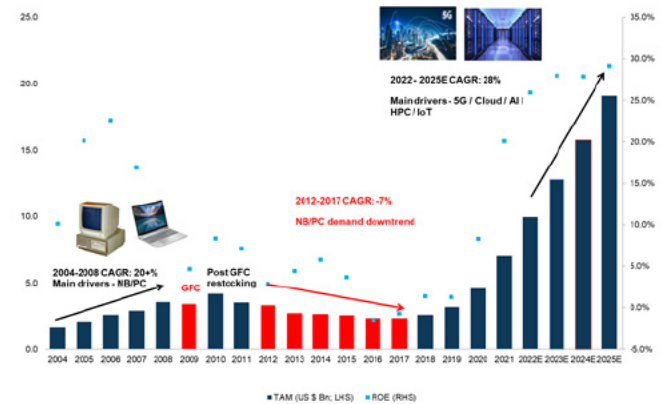
Exhibit 12: Taiwan ABF substrates suppliers' ASP growth rate will continue to be strong in the coming years, despite no (or limited) like-for-like base pricing hikes after 2023

Rebased 2018 ABF ASP at 1



Source: Company data, Goldman Sachs Global Investment Research

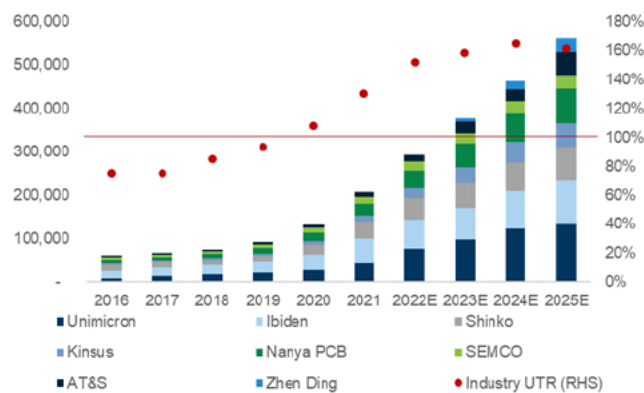
Exhibit 13: ABF demand (US\$bn) to deliver solid growth in the coming years



Source: Company data, Goldman Sachs Global Investment Research

Exhibit 14: ABF industry utilization rate to remain tight with solid demand uptrend

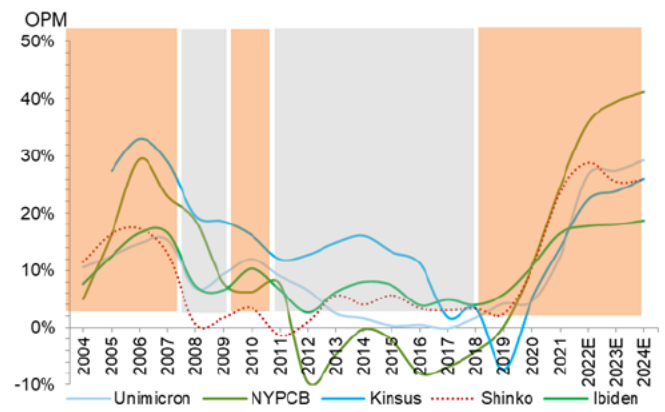
ABF revenue (NT\$m)



Not Covered company AT&S estimates are per BBG consensus

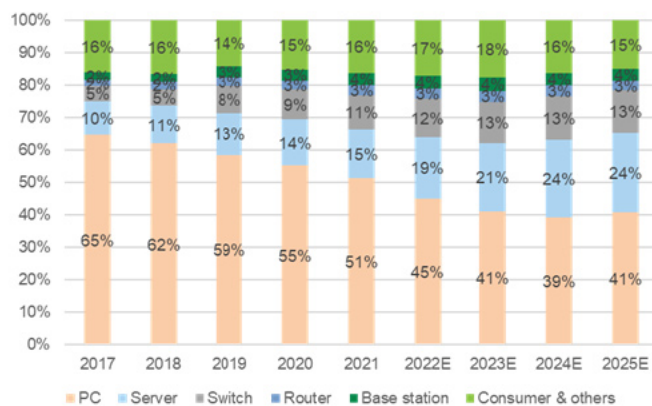
Source: Company data, Goldman Sachs Global Investment Research, Bloomberg

Exhibit 15: We expect ABF suppliers to continue to enjoy strong OPM growth



Source: Company data, Goldman Sachs Global Investment Research

Exhibit 16: ABF substrate demand breakdown by end markets



Source: Company data, Goldman Sachs Global Investment Research

Exhibit 17: Key ABF suppliers' capacity expansion calendar

Company	Plant	1Q22	2Q22	3Q22	4Q22	1Q23	2Q23	3Q23	4Q23	1Q24	2Q24	3Q24	4Q24	1Q25	2Q25	3Q25	4Q25	1Q26	
Unimicron	Yangmei	42% additional capacity (vs. end of 2021)																	
	KF																		TBA
	Shulin phase 1																		
NYPGB	Kunshan phase 2																		
	Shulin phase 2																		
Kinsus	Xinfeng																		
	Yangmei																		
Zhen Dng	Shenzhen phase 1																		
	Shenzhen phase 2																		
Biden	Phase 2																		
	Phase 3																		
Shinko	Kohoku & Wakaho																		
	new Chikuma plant																		
AT&S	Chongqing III																		
	Kulim																		

Source: Company data, Goldman Sachs Global Investment Research

Exhibit 18: Our Unimicron ABF key assumptions

	2017	2018	2019	2020	2021	2022E	2023E	2024E
ABF revenue (NT \$mn)	14,473	17,573	20,685	26,295	42,845	77,403	98,367	122,934
Revenue YoY	66%	21%	18%	27%	63%	81%	27%	25%
Shipment growth	66%	19%	14%	22%	49%	55%	13%	19%
ASP growth	0%	2%	4%	4%	9%	17%	12%	5%
Utilization rate	75%	85%	86%	97%	112%	132%	123%	122%
ABF capacity increase	0%	5%	13%	7%	30%	31%	22%	20%
ABF ASP (2017 rebased at 1)	1.00	1.02	1.06	1.10	1.21	1.41	1.58	1.65
ABF GM	15.2%	18.1%	21.0%	22.6%	34.7%	50.7%	52.0%	52.8%
COGS	0.85	0.84	0.83	0.85	0.79	0.69	0.76	0.78
Material	0.47	0.47	0.47	0.49	0.50	0.52	0.57	0.59
Labor	0.08	0.08	0.08	0.08	0.07	0.05	0.04	0.04
Overhead	0.30	0.29	0.28	0.28	0.22	0.12	0.15	0.15
ABF OPM	6.3%	8.8%	12.6%	12.5%	24.6%	42.0%	43.4%	44.5%
ABF OP (NT \$ mn)	916	1,553	2,600	3,296	10,558	32,547	42,740	54,755
% of Unimicron's total OP	-8928%	112%	74%	82%	80%	86%	93%	95%

Source: Company data, Goldman Sachs Global Investment Research

Exhibit 19: Our NYPCB ABF key assumptions

	2017	2018	2019	2020	2021	2022E	2023E	2024E
ABF revenue (NT \$mn)	8,519	9,758	11,957	17,588	26,462	38,686	54,698	66,948
Revenue YoY	-11%	15%	23%	47%	50%	46%	41%	22%
Shipment growth	-10%	-10%	14%	22%	18%	9%	28%	17%
ASP growth	-1%	0%	7%	21%	28%	34%	9%	5%
Utilization rate	56%	64%	78%	97%	98%	99%	99%	99%
ABF capacity increase	0%	0%	-11%	5%	7%	18%	22%	9%
ABF ASP (2017 rebased at 1)	1.00	1.00	1.07	1.29	1.66	2.22	2.41	2.53
ABF GM	(6.5%)	(4.2%)	12.4%	23.3%	39.6%	52.3%	55.1%	56.1%
COGS	1.07	1.07	0.94	0.99	1.00	1.06	1.08	1.11
Material	0.59	0.59	0.59	0.61	0.63	0.66	0.66	0.66
Labor	0.11	0.11	0.07	0.08	0.07	0.07	0.08	0.08
Overhead	0.37	0.37	0.28	0.30	0.30	0.33	0.34	0.37
ABF OPM	-12.1%	-9.6%	7.4%	19.1%	36.7%	48.4%	53.4%	55.8%
ABF OP (NT \$ mn)	(1,034)	(934)	889	3,353	9,723	18,719	29,224	37,324
% of NYPCB's total OP	57%	79%	1247%	82%	76%	83%	91%	91%

Source: Company data, Goldman Sachs Global Investment Research

Exhibit 20: Our Kinsus ABF key assumptions

	2017	2018	2019	2020	2021	2022E	2023E	2024E
ABF revenue (NT \$mn)	4,173	4,644	5,506	8,185	12,990	23,926	35,287	47,210
Revenue YoY		11%	19%	49%	59%	84%	47%	34%
Shipment growth		10%	16%	40%	44%	62%	33%	27%
ASP growth		1%	2%	6%	10%	14%	11%	5%
ABF capacity increase		0%	5%	37%	42%	44%	52%	24%
ABF ASP (2017 rebased at 1)	1.00	1.01	1.04	1.10	1.21	1.38	1.53	1.60
ABF GM	33.0%	35.6%	30.7%	32.7%	36.6%	44.8%	46.2%	47.2%
COGS	0.67	0.65	0.72	0.74	0.77	0.81	0.82	0.85
Material	0.37	0.36	0.40	0.41	0.43	0.45	0.49	0.51
Labor	0.07	0.06	0.07	0.07	0.07	0.08	0.08	0.08
Overhead	0.23	0.23	0.25	0.26	0.26	0.28	0.26	0.26
ABF OPM	19.0%	21.6%	15.7%	17.2%	21.1%	29.8%	30.7%	31.7%
ABF OP (NT \$ mn)	793	1,002	863	1,406	2,746	7,138	10,819	14,966
% of Kinsus' total OP	199%	127%	-52%	105%	55%	68%	78%	80%

Source: Company data, Goldman Sachs Global Investment Research

Exhibit 21: Unimicron's P&L

NT\$mn	1Q21	2Q21	3Q21	4Q21	1Q22	2Q22	3Q22E	4Q22E	1Q23E	2Q23E	3Q23E	4Q23E	2020	2021	2022E	2023E	2024E
Revenue	21,823	24,031	28,145	30,564	30,711	35,635	36,699	37,224	36,007	38,145	45,346	47,321	87,893	104,563	140,269	166,819	197,286
Gross profit	3,755	4,650	6,792	8,466	9,923	13,469	13,393	13,712	13,030	13,940	16,572	17,463	12,828	23,663	50,497	61,005	75,133
Operating expense	(2,521)	(2,606)	(2,618)	(2,748)	(2,734)	(3,119)	(3,376)	(3,574)	(3,532)	(3,635)	(3,959)	(3,994)	(8,811)	(10,493)	(12,803)	(15,120)	(17,282)
Operating income	1,234	2,044	4,174	5,718	7,189	10,350	10,016	10,139	9,498	10,305	12,613	13,469	4,017	13,170	37,694	45,885	57,851
Pretax income	2,548	2,374	5,302	6,405	7,491	11,108	10,176	10,303	9,651	10,454	12,762	13,698	6,234	16,629	39,077	46,565	58,011
Taxes expense	(353)	(549)	(964)	(1,240)	(1,605)	(2,720)	(2,137)	(2,164)	(2,027)	(2,609)	(2,680)	(2,672)	(917)	(3,104)	(8,625)	(9,887)	(12,317)
Net income	2,183	1,828	4,215	4,996	5,667	8,030	7,914	7,984	7,404	7,825	10,052	10,777	5,462	13,222	29,595	36,058	45,073
EPS, NTS	1.49	1.24	2.87	3.38	3.85	5.44	5.36	5.41	5.02	5.30	6.81	7.30	3.74	8.98	20.06	24.44	30.55
Ratio analysis and assumption																	
As % of sales																	
Gross margin	17.2%	19.4%	24.1%	27.7%	32.3%	37.8%	36.5%	36.8%	36.2%	36.5%	36.5%	36.9%	14.6%	22.6%	36.0%	36.6%	38.1%
Operating expense ratio	11.6%	10.8%	9.3%	9.0%	8.9%	8.8%	9.2%	9.6%	9.8%	9.5%	8.7%	8.4%	10.0%	10.0%	9.1%	9.1%	8.8%
Operating margin	5.7%	8.5%	14.8%	18.7%	23.4%	29.0%	27.3%	27.2%	26.4%	27.0%	27.8%	28.6%	4.6%	12.6%	26.9%	27.5%	29.3%
Net margin	10.0%	7.6%	15.0%	16.3%	18.5%	22.5%	21.4%	21.4%	20.6%	20.5%	22.2%	22.8%	6.2%	12.6%	21.1%	21.6%	22.8%
QoQ growth (%)																	
Revenue	-3.3%	10.1%	17.1%	8.6%	0.5%	16.0%	3.0%	1.4%	-3.3%	5.9%	18.9%	4.4%	-	-	-	-	-
Gross profit	17.4%	23.8%	46.1%	24.6%	17.2%	36.7%	-0.6%	2.4%	-5.0%	7.0%	18.9%	5.4%	-	-	-	-	-
Operating income	75.1%	65.6%	104.2%	37.0%	25.7%	44.0%	-3.2%	1.2%	-6.3%	8.5%	22.4%	6.8%	-	-	-	-	-
Net income	6.6%	-16.3%	130.6%	18.5%	13.4%	41.7%	-1.4%	0.9%	-7.3%	5.7%	28.5%	7.2%	-	-	-	-	-
YoY growth (%)																	
Revenue	6.1%	10.7%	22.2%	35.4%	40.7%	48.3%	30.4%	21.8%	17.2%	7.0%	23.6%	27.1%	6%	19%	34%	19%	18%
Gross profit	31.4%	36.0%	102.7%	164.6%	164.2%	189.7%	97.2%	62.0%	31.3%	3.5%	23.7%	27.4%	13%	84%	113%	21%	23%
Operating income	44.7%	64.8%	265.8%	710.9%	482.4%	406.4%	139.9%	77.3%	32.1%	-0.4%	25.9%	32.9%	15%	228%	186%	22%	26%
Net income	472.1%	27.3%	164.2%	143.8%	159.5%	339.4%	87.8%	59.8%	30.7%	-2.6%	27.0%	35.0%	68%	142%	124%	22%	25%

Source: Company data, Goldman Sachs Global Investment Research

Kinsus (3189.TW, Buy): Maintain Buy with an unchanged 12-m TP of NT\$250 (based on an unchanged 11x 2023E EPS; 0.4 s.d. lower than the past 2-year average one-year forward PE multiple). Key risks: (1) faster-than-expected capacity expansion from other ABF peers, (2) acceleration in China semiconductor localization, and (3) slower-than-expected smartphone sales.

Disclosure Appendix

Reg AC

I, James Wang, hereby certify that all of the views expressed in this report accurately reflect my personal views about the subject company or companies and its or their securities. I also certify that no part of my compensation was, is or will be, directly or indirectly, related to the specific recommendations or views expressed in this report.

Unless otherwise stated, the individuals listed on the cover page of this report are analysts in Goldman Sachs' Global Investment Research division.

GS Factor Profile

The Goldman Sachs Factor Profile provides investment context for a stock by comparing key attributes to the market (i.e. our coverage universe) and its sector peers. The four key attributes depicted are: Growth, Financial Returns, Multiple (e.g. valuation) and Integrated (a composite of Growth, Financial Returns and Multiple). Growth, Financial Returns and Multiple are calculated by using normalized ranks for specific metrics for each stock. The normalized ranks for the metrics are then averaged and converted into percentiles for the relevant attribute. The precise calculation of each metric may vary depending on the fiscal year, industry and region, but the standard approach is as follows:

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).

Financial Returns and Multiple use the Goldman Sachs analyst forecasts at the fiscal year-end at least three quarters in the future. Growth uses inputs for the fiscal year at least seven quarters in the future compared with the year at least three quarters in the future (on a per-share basis for all metrics).

For a more detailed description of how we calculate the GS Factor Profile, please contact your GS representative.

M&A Rank

Across our global coverage, we examine stocks using an M&A framework, considering both qualitative factors and quantitative factors (which may vary across sectors and regions) to incorporate the potential that certain companies could be acquired. We then assign a M&A rank as a means of scoring companies under our rated coverage from 1 to 3, with 1 representing high (30%-50%) probability of the company becoming an acquisition target, 2 representing medium (15%-30%) probability and 3 representing low (0%-15%) probability. For companies ranked 1 or 2, in line with our standard departmental guidelines we incorporate an M&A component into our target price. M&A rank of 3 is considered immaterial and therefore does not factor into our price target, and may or may not be discussed in research.

Quantum

Quantum is Goldman Sachs' proprietary database providing access to detailed financial statement histories, forecasts and ratios. It can be used for in-depth analysis of a single company, or to make comparisons between companies in different sectors and markets.

Disclosures

The rating(s) for Kinsus, NYPCB and Unimicron Technology is/are relative to the other companies in its/their coverage universe: Advantech Corp., Airtac International Group, BizLink Holding, Chroma ATE, Delta Electronics, Elite Material, Flexium Interconnect, GCE, Hiwin Corp., ITEQ Corp, Kinsus, Lotes, NYPCB, Taiwan Union Technology Corp., Unimicron Technology, Win Semiconductors Corp., Yageo Corp., Zhen Ding Technology Holding

Company-specific regulatory disclosures

The following disclosures relate to relationships between The Goldman Sachs Group, Inc. (with its affiliates, "Goldman Sachs") and companies covered by the Global Investment Research Division of Goldman Sachs and referred to in this research.

Goldman Sachs beneficially owned 1% or more of common equity (excluding positions managed by affiliates and business units not required to be aggregated under US securities law) as of the month end preceding this report: Kinsus (NT\$125.50) and Unimicron Technology (NT\$154.50)

Goldman Sachs has received compensation for non-investment banking services during the past 12 months: NYPCB (NT\$270.00)

Goldman Sachs had a non-securities services client relationship during the past 12 months with: NYPCB (NT\$270.00)

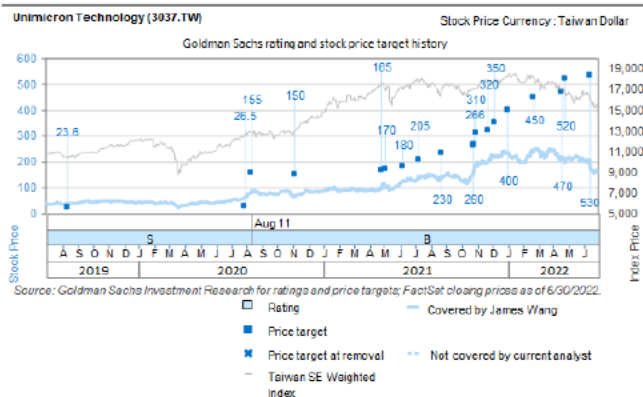
Distribution of ratings/investment banking relationships

Goldman Sachs Investment Research global Equity coverage universe

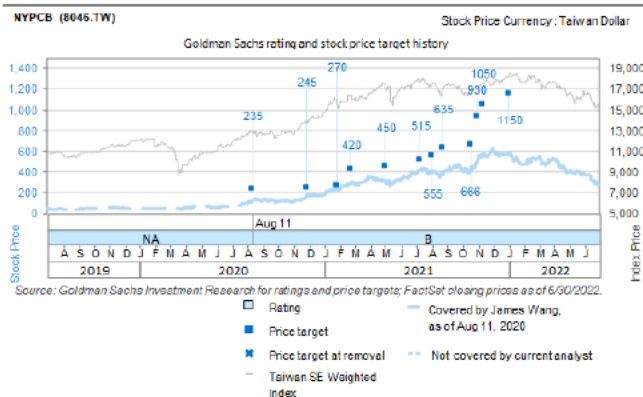
	Rating Distribution			Investment Banking Relationships		
	Buy	Hold	Sell	Buy	Hold	Sell
Global	50%	35%	15%	65%	58%	45%

As of July 1, 2022, Goldman Sachs Global Investment Research had investment ratings on 3,132 equity securities. Goldman Sachs assigns stocks as Buys and Sells on various regional Investment Lists; stocks not so assigned are deemed Neutral. Such assignments equate to Buy, Hold and Sell for the purposes of the above disclosure required by the FINRA Rules. See 'Ratings, Coverage universe and related definitions' below. The Investment Banking Relationships chart reflects the percentage of subject companies within each rating category for whom Goldman Sachs has provided investment banking services within the previous twelve months.

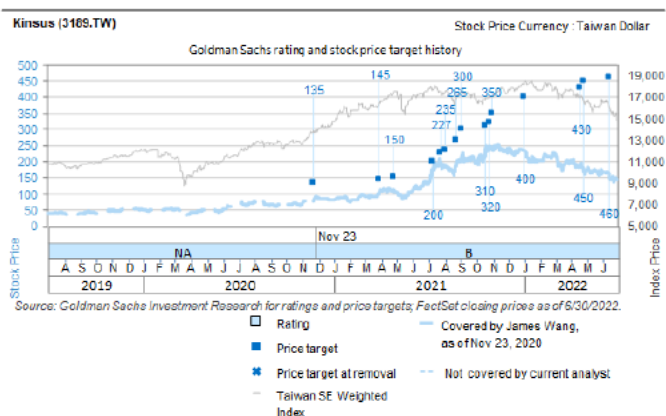
Price target and rating history chart(s)



The price targets shown should be considered in the context of all prior published Goldman Sachs research, which may or may not have included price targets, as well as developments relating to the company, its industry and financial markets.



The price targets shown should be considered in the context of all prior published Goldman Sachs research, which may or may not have included price targets, as well as developments relating to the company, its industry and financial markets.



The price targets shown should be considered in the context of all prior published Goldman Sachs research, which may or may not have included price targets, as well as developments relating to the company, its industry and financial markets.

Regulatory disclosures

Disclosures required by United States laws and regulations

See company-specific regulatory disclosures above for any of the following disclosures required as to companies referred to in this report: manager or co-manager in a pending transaction; 1% or other ownership; compensation for certain services; types of client relationships; managed/co-managed public offerings in prior periods; directorships; for equity securities, market making and/or specialist role. Goldman Sachs trades or may trade as a principal in debt securities (or in related derivatives) of issuers discussed in this report.

The following are additional required disclosures: **Ownership and material conflicts of interest:** Goldman Sachs policy prohibits its analysts, professionals reporting to analysts and members of their households from owning securities of any company in the analyst's area of coverage.

Analyst compensation: Analysts are paid in part based on the profitability of Goldman Sachs, which includes investment banking revenues. **Analyst as officer or director:** Goldman Sachs policy generally prohibits its analysts, persons reporting to analysts or members of their households from serving as an officer, director or advisor of any company in the analyst's area of coverage. **Non-U.S. Analysts:** Non-U.S. analysts may not be associated persons of Goldman Sachs & Co. LLC and therefore may not be subject to FINRA Rule 2241 or FINRA Rule 2242 restrictions on communications with subject company, public appearances and trading securities held by the analysts.

Distribution of ratings: See the distribution of ratings disclosure above. **Price chart:** See the price chart, with changes of ratings and price targets in prior periods, above, or, if electronic format or if with respect to multiple companies which are the subject of this report, on the Goldman Sachs website at <https://www.gs.com/research/hedge.html>.

Additional disclosures required under the laws and regulations of jurisdictions other than the United States

The following disclosures are those required by the jurisdiction indicated, except to the extent already made above pursuant to United States laws and regulations. **Australia:** Goldman Sachs Australia Pty Ltd and its affiliates are not authorised deposit-taking institutions (as that term is defined in the Banking Act 1959 (Cth)) in Australia and do not provide banking services, nor carry on a banking business, in Australia. This research, and any access to it, is intended only for "wholesale clients" within the meaning of the Australian Corporations Act, unless otherwise agreed by Goldman Sachs. In producing research reports, members of the Global Investment Research Division of Goldman Sachs Australia may attend site visits and other meetings hosted by the companies and other entities which are the subject of its research reports. In some instances the costs of such site visits or meetings may be met in part or in whole by the issuers concerned if Goldman Sachs Australia considers it is appropriate and reasonable in the specific circumstances relating to the site visit or meeting. To the extent that the contents of this document contains any financial product advice, it is general advice only and has been prepared by Goldman Sachs without taking into account a client's objectives, financial situation or needs. A client should, before acting on any such advice, consider the appropriateness of the advice having regard to the client's own objectives, financial situation and needs. A copy of certain Goldman Sachs Australia and New Zealand disclosure of interests and a copy of Goldman Sachs' Australian Sell-Side Research Independence Policy Statement are available at: <https://www.goldmansachs.com/disclosures/australia-new-zealand/index.html>. **Brazil:** Disclosure

information in relation to CVM Resolution n. 20 is available at <https://www.gs.com/worldwide/brazil/area/gir/index.html>. Where applicable, the Brazil-registered analyst primarily responsible for the content of this research report, as defined in Article 20 of CVM Resolution n. 20, is the first author named at the beginning of this report, unless indicated otherwise at the end of the text. **Canada:** This information is being provided to you for information purposes only and is not, and under no circumstances should be construed as, an advertisement, offering or solicitation by Goldman Sachs & Co. LLC for purchasers of securities in Canada to trade in any Canadian security. Goldman Sachs & Co. LLC is not registered as a dealer in any jurisdiction in Canada under applicable Canadian securities laws and generally is not permitted to trade in Canadian securities and may be prohibited from selling certain securities and products in certain jurisdictions in Canada. If you wish to trade in any Canadian securities or other products in Canada please contact Goldman Sachs Canada Inc., an affiliate of The Goldman Sachs Group Inc., or another registered Canadian dealer. **Hong Kong:** Further information on the securities of covered companies referred to in this research may be obtained on request from Goldman Sachs (Asia) L.L.C. **India:** Further information on the subject company or companies referred to in this research may be obtained from Goldman Sachs (India) Securities Private Limited, Research Analyst - SEBI Registration Number INH000001493, 951-A, Rational House, Appasaheb Marathe Marg, Prabhadevi, Mumbai 400 025, India, Corporate Identity Number U74140MH2006FTC160634, Phone +91 22 6616 9000, Fax +91 22 6616 9001. Goldman Sachs may beneficially own 1% or more of the securities (as such term is defined in clause 2 (h) the Indian Securities Contracts (Regulation) Act, 1956) of the subject company or companies referred to in this research report. **Japan:** See below. **Korea:** This research, and any access to it, is intended only for "professional investors" within the meaning of the Financial Services and Capital Markets Act, unless otherwise agreed by Goldman Sachs. Further information on the subject company or companies referred to in this research may be obtained from Goldman Sachs (Asia) L.L.C., Seoul Branch. **New Zealand:** Goldman Sachs New Zealand Limited and its affiliates are neither "registered banks" nor "deposit takers" (as defined in the Reserve Bank of New Zealand Act 1989) in New Zealand. This research, and any access to it, is intended for "wholesale clients" (as defined in the Financial Advisers Act 2008) unless otherwise agreed by Goldman Sachs. A copy of certain Goldman Sachs Australia and New Zealand disclosure of interests is available at: <https://www.goldmansachs.com/disclosures/australia-new-zealand/index.html>. **Russia:** Research reports distributed in the Russian Federation are not advertising as defined in the Russian legislation, but are information and analysis not having product promotion as their main purpose and do not provide appraisal within the meaning of the Russian legislation on appraisal activity. Research reports do not constitute a personalized investment recommendation as defined in Russian laws and regulations, are not addressed to a specific client, and are prepared without analyzing the financial circumstances, investment profiles or risk profiles of clients. Goldman Sachs assumes no responsibility for any investment decisions that may be taken by a client or any other person based on this research report. **Singapore:** Goldman Sachs (Singapore) Pte. (Company Number: 198602165W), which is regulated by the Monetary Authority of Singapore, accepts legal responsibility for this research, and should be contacted with respect to any matters arising from, or in connection with, this research. **Taiwan:** This material is for reference only and must not be reprinted without permission. Investors should carefully consider their own investment risk. Investment results are the responsibility of the individual investor. **United Kingdom:** Persons who would be categorized as retail clients in the United Kingdom, as such term is defined in the rules of the Financial Conduct Authority, should read this research in conjunction with prior Goldman Sachs research on the covered companies referred to herein and should refer to the risk warnings that have been sent to them by Goldman Sachs International. A copy of these risks warnings, and a glossary of certain financial terms used in this report, are available from Goldman Sachs International on request.

European Union and United Kingdom: Disclosure information in relation to Article 6 (2) of the European Commission Delegated Regulation (EU) (2016/958) supplementing Regulation (EU) No 596/2014 of the European Parliament and of the Council (including as that Delegated Regulation is implemented into United Kingdom domestic law and regulation following the United Kingdom's departure from the European Union and the European Economic Area) with regard to regulatory technical standards for the technical arrangements for objective presentation of investment recommendations or other information recommending or suggesting an investment strategy and for disclosure of particular interests or indications of conflicts of interest is available at <https://www.gs.com/disclosures/europeanpolicy.html> which states the European Policy for Managing Conflicts of Interest in Connection with Investment Research.

Japan: Goldman Sachs Japan Co., Ltd. is a Financial Instrument Dealer registered with the Kanto Financial Bureau under registration number Kinsho 69, and a member of Japan Securities Dealers Association, Financial Futures Association of Japan and Type II Financial Instruments Firms Association. Sales and purchase of equities are subject to commission pre-determined with clients plus consumption tax. See company-specific disclosures as to any applicable disclosures required by Japanese stock exchanges, the Japanese Securities Dealers Association or the Japanese Securities Finance Company.

Ratings, coverage universe and related definitions

Buy (B), Neutral (N), Sell (S) Analysts recommend stocks as Buys or Sells for inclusion on various regional Investment Lists. Being assigned a Buy or Sell on an Investment List is determined by a stock's total return potential relative to its coverage universe. Any stock not assigned as a Buy or a Sell on an Investment List with an active rating (i.e., a stock that is not Rating Suspended, Not Rated, Coverage Suspended or Not Covered), is deemed Neutral. Each region's Investment Review Committee manages Regional Conviction lists, which represent investment recommendations focused on the size of the total return potential and/or the likelihood of the realization of the return across their respective areas of coverage. The addition or removal of stocks from such Conviction lists do not represent a change in the analysts' investment rating for such stocks.

Total return potential represents the upside or downside differential between the current share price and the price target, including all paid or anticipated dividends, expected during the time horizon associated with the price target. Price targets are required for all covered stocks. The total return potential, price target and associated time horizon are stated in each report adding or reiterating an Investment List membership.

Coverage Universe: A list of all stocks in each coverage universe is available by primary analyst, stock and coverage universe at <https://www.gs.com/research/hedge.html>.

Not Rated (NR). The investment rating, target price and earnings estimates (where relevant) have been suspended pursuant to Goldman Sachs policy when Goldman Sachs is acting in an advisory capacity in a merger or in a strategic transaction involving this company, when there are legal, regulatory or policy constraints due to Goldman Sachs' involvement in a transaction, and in certain other circumstances. **Rating Suspended (RS).** Goldman Sachs Research has suspended the investment rating and price target for this stock, because there is not a sufficient fundamental basis for determining an investment rating or target price. The previous investment rating and target price, if any, are no longer in effect for this stock and should not be relied upon. **Coverage Suspended (CS).** Goldman Sachs has suspended coverage of this company. **Not Covered (NC).** Goldman Sachs does not cover this company. **Not Available or Not Applicable (NA).** The information is not available for display or is not applicable. **Not Meaningful (NM).** The information is not meaningful and is therefore excluded.

Global product; distributing entities

The Global Investment Research Division of Goldman Sachs produces and distributes research products for clients of Goldman Sachs on a global basis. Analysts based in Goldman Sachs offices around the world produce research on industries and companies, and research on macroeconomics, currencies, commodities and portfolio strategy. This research is disseminated in Australia by Goldman Sachs Australia Pty Ltd (ABN 21 006 797 897); in Brazil by Goldman Sachs do Brasil Corretora de Títulos e Valores Mobiliários S.A.; Public Communication Channel Goldman Sachs Brazil: 0800 727 5764 and / or contatogoldmanbrasil@gs.com. Available Weekdays (except holidays), from 9am to 6pm. Canal de Comunicação com o Público Goldman Sachs Brasil: 0800 727 5764 e/ou contatogoldmanbrasil@gs.com. Horário de funcionamento: segunda-feira à sexta-feira (exceto feriados), das 9h às 18h; in Canada by Goldman Sachs & Co. LLC; in Hong Kong by Goldman Sachs (Asia) L.L.C.; in India by Goldman Sachs (India) Securities Private Ltd.; in Japan by Goldman Sachs Japan Co., Ltd.; in the Republic of Korea by Goldman Sachs (Asia) L.L.C., Seoul Branch; in New Zealand by Goldman Sachs New Zealand Limited; in Russia by OOO Goldman Sachs; in Singapore by Goldman Sachs (Singapore) Pte. (Company Number: 198602165W); and in the

United States of America by Goldman Sachs & Co. LLC. Goldman Sachs International has approved this research in connection with its distribution in the United Kingdom.

Effective from the date of the United Kingdom's departure from the European Union and the European Economic Area ("Brexit Day") the following information with respect to distributing entities will apply:

Goldman Sachs International ("GSI"), authorised by the Prudential Regulation Authority ("PRA") and regulated by the Financial Conduct Authority ("FCA") and the PRA, has approved this research in connection with its distribution in the United Kingdom.

European Economic Area: GSI, authorised by the PRA and regulated by the FCA and the PRA, disseminates research in the following jurisdictions within the European Economic Area: the Grand Duchy of Luxembourg, Italy, the Kingdom of Belgium, the Kingdom of Denmark, the Kingdom of Norway, the Republic of Finland, the Republic of Cyprus and the Republic of Ireland; GS - Succursale de Paris (Paris branch) which, from Brexit Day, will be authorised by the French Autorité de contrôle prudentiel et de résolution ("ACPR") and regulated by the Autorité de contrôle prudentiel et de résolution and the Autorité des marchés financiers ("AMF") disseminates research in France; GSI - Sucursal en España (Madrid branch) authorized in Spain by the Comisión Nacional del Mercado de Valores disseminates research in the Kingdom of Spain; GSI - Sweden Bankfilial (Stockholm branch) is authorized by the SFSa as a "third country branch" in accordance with Chapter 4, Section 4 of the Swedish Securities and Market Act (Sw. lag (2007:528) om värdepappersmarknaden) disseminates research in the Kingdom of Sweden; Goldman Sachs Bank Europe SE ("GSBE") is a credit institution incorporated in Germany and, within the Single Supervisory Mechanism, subject to direct prudential supervision by the European Central Bank and in other respects supervised by German Federal Financial Supervisory Authority (Bundesanstalt für Finanzdienstleistungsaufsicht, BaFin) and Deutsche Bundesbank and disseminates research in the Federal Republic of Germany and those jurisdictions within the European Economic Area where GSI is not authorised to disseminate research and additionally, GSBE, Copenhagen Branch filial af GSBE, Tyskland, supervised by the Danish Financial Authority disseminates research in the Kingdom of Denmark; GSBE - Sucursal en España (Madrid branch) subject (to a limited extent) to local supervision by the Bank of Spain disseminates research in the Kingdom of Spain; GSBE - Succursale Italia (Milan branch) to the relevant applicable extent, subject to local supervision by the Bank of Italy (Banca d'Italia) and the Italian Companies and Exchange Commission (Commissione Nazionale per le Società e la Borsa "Consob") disseminates research in Italy; GSBE - Succursale de Paris (Paris branch), supervised by the AMF and by the ACPR disseminates research in France; and GSBE - Sweden Bankfilial (Stockholm branch), to a limited extent, subject to local supervision by the Swedish Financial Supervisory Authority (Finansinspektionen) disseminates research in the Kingdom of Sweden.

General disclosures

This research is for our clients only. Other than disclosures relating to Goldman Sachs, this research is based on current public information that we consider reliable, but we do not represent it is accurate or complete, and it should not be relied on as such. The information, opinions, estimates and forecasts contained herein are as of the date hereof and are subject to change without prior notification. We seek to update our research as appropriate, but various regulations may prevent us from doing so. Other than certain industry reports published on a periodic basis, the large majority of reports are published at irregular intervals as appropriate in the analyst's judgment.

Goldman Sachs conducts a global full-service, integrated investment banking, investment management, and brokerage business. We have investment banking and other business relationships with a substantial percentage of the companies covered by our Global Investment Research Division. Goldman Sachs & Co. LLC, the United States broker dealer, is a member of SIPC (<https://www.sipc.org>).

Our salespeople, traders, and other professionals may provide oral or written market commentary or trading strategies to our clients and principal trading desks that reflect opinions that are contrary to the opinions expressed in this research. Our asset management area, principal trading desks and investing businesses may make investment decisions that are inconsistent with the recommendations or views expressed in this research.

The analysts named in this report may have from time to time discussed with our clients, including Goldman Sachs salespersons and traders, or may discuss in this report, trading strategies that reference catalysts or events that may have a near-term impact on the market price of the equity securities discussed in this report, which impact may be directionally counter to the analyst's published price target expectations for such stocks. Any such trading strategies are distinct from and do not affect the analyst's fundamental equity rating for such stocks, which rating reflects a stock's return potential relative to its coverage universe as described herein.

We and our affiliates, officers, directors, and employees, excluding equity and credit analysts, will from time to time have long or short positions in, act as principal in, and buy or sell, the securities or derivatives, if any, referred to in this research.

The views attributed to third party presenters at Goldman Sachs arranged conferences, including individuals from other parts of Goldman Sachs, do not necessarily reflect those of Global Investment Research and are not an official view of Goldman Sachs.

Any third party referenced herein, including any salespeople, traders and other professionals or members of their household, may have positions in the products mentioned that are inconsistent with the views expressed by analysts named in this report.

This research is not an offer to sell or the solicitation of an offer to buy any security in any jurisdiction where such an offer or solicitation would be illegal. It does not constitute a personal recommendation or take into account the particular investment objectives, financial situations, or needs of individual clients. Clients should consider whether any advice or recommendation in this research is suitable for their particular circumstances and, if appropriate, seek professional advice, including tax advice. The price and value of investments referred to in this research and the income from them may fluctuate. Past performance is not a guide to future performance, future returns are not guaranteed, and a loss of original capital may occur. Fluctuations in exchange rates could have adverse effects on the value or price of, or income derived from, certain investments.

Certain transactions, including those involving futures, options, and other derivatives, give rise to substantial risk and are not suitable for all investors. Investors should review current options and futures disclosure documents which are available from Goldman Sachs sales representatives or at <https://www.theocc.com/about/publications/character-risks.jsp> and https://www.fiadocumentation.org/fia/regulatory-disclosures_1/fia-uniform-futures-and-options-on-futures-risk-disclosures-booklet-pdf-version-2018.

Transaction costs may be significant in option strategies calling for multiple purchase and sales of options such as spreads. Supporting documentation will be supplied upon request.

Differing Levels of Service provided by Global Investment Research: The level and types of services provided to you by the Global Investment Research division of GS may vary as compared to that provided to internal and other external clients of GS, depending on various factors including your individual preferences as to the frequency and manner of receiving communication, your risk profile and investment focus and perspective (e.g., marketwide, sector specific, long term, short term), the size and scope of your overall client relationship with GS, and legal and regulatory constraints. As an example, certain clients may request to receive notifications when research on specific securities is published, and certain clients may request that specific data underlying analysts' fundamental analysis available on our internal client websites be delivered to them electronically through data feeds or otherwise. No change to an analyst's fundamental research views (e.g., ratings, price targets, or material changes to earnings estimates for equity securities), will be communicated to any client prior to inclusion of such information in a research report broadly disseminated through electronic publication to our internal client websites or through other means, as necessary, to all clients who are entitled to receive such reports.

All research reports are disseminated and available to all clients simultaneously through electronic publication to our internal client websites. Not all research content is redistributed to our clients or available to third-party aggregators, nor is Goldman Sachs responsible for the redistribution of our

research by third party aggregators. For research, models or other data related to one or more securities, markets or asset classes (including related services) that may be available to you, please contact your GS representative or go to <https://research.gs.com>.

Disclosure information is also available at <https://www.gs.com/research/hedge.html> or from Research Compliance, 200 West Street, New York, NY 10282.

© 2022 Goldman Sachs.

No part of this material may be (i) copied, photocopied or duplicated in any form by any means or (ii) redistributed without the prior written consent of The Goldman Sachs Group, Inc.