

Memory Semis Monthly

April '21 Edition: Should we be concerned about an inventory build?

Equities

Global

Semiconductors

Nicolas Gaudois

Analyst

nicolas.gaudois@ubs.com

+852-2971 5681

Timothy Arcuri

Analyst

timothy.arcuri@ubs.com

+1-415-352 5676

Kenji Yasui

Analyst

kenji.yasui@ubs.com

+81-3-5208 6211

Munjal Shah

Analyst

munjal.shah@ubs.com

+1-212-713 2113

Taewoo Lee

Analyst

taewoo.lee@ubs.com

+852-2971 6873

Pradeep Ramani

Analyst

pradeep.ramani@ubs.com

+1-415-352 5517

Jimmy Yoon

Associate Analyst

jimmy.yoon@ubs.com

+852-3712 4671

David Mulholland, CFA

Analyst

david.mulholland@ubs.com

+44-20-7568 4069

Sunny Lin

Analyst

sunny.lin@ubs.com

+886-2-8722 7346

DRAM customer inventories slightly on the higher side but not out of control

Recently, investors have grown more concerned about memory inventories at customers, notably DRAM. Our updated estimates indicate that hyperscale customers' server DRAM inventories are close to 8-10 weeks, actually down from a broader range of 10-15 weeks in 1Q21. We caution though on inherent volatility of those numbers. For smartphone customers, they are we estimate close to 6 weeks (stable), and for PC customers/server OEMs, 4-6 weeks (also stable). As we indicated in our last update ([link](#)), this is somewhat on the higher side for hyperscale customers, and slightly so for smartphone vendors. For NAND flash, they remain we estimate close to 3-5 weeks, which is normal to relatively low.

Should this be cause for concern? We do not think so

Even with DRAM inventories slightly on the higher side, we believe large customers, notably hyperscalers, are trying to increase inventories further in 2Q. This is, in our view, justified: 1/ We forecast DRAM shipments from memory makers to undergrow end-consumption by close to 2% (industry bit supply growth: +19.7% YoY in '21E; end-consumption +22.1%). 2/ We expect hyperscale server unit procurement to continue to increase into 2H21, and, very likely so, 2022. 3/ DRAM is now, as we predicted, in shortages for smaller customers (notably PC), which makes building inventory buffer for those customers who can, a prudent policy. This is a very different set-up from 2018 when we saw hyperscale DRAM inventory build ahead of a negative turn in server procurement in 2H18.

Semis manufacturing equipment delivery pull-ins not before 4Q21

SK Hynix confirmed pulling in some of its planned equipment delivery for 1H22 into 4Q21 for DRAM manufacturing. We believe this is both for M14 (tech migration) and M16 (new capacity – we estimate c. 15k wpm). This is very much in line with our prior research ([link](#)). We increased '21E capex to Won13tn (was Won11tn) with further upside likely limited. Whilst Samsung did not make such comments yet, we believe they will very likely take similar actions, for both DRAM and NAND. This does not change our expectation of the DRAM upcycle extending into 3Q22, and NAND 1Q22.

Remaining positive on memory semis with DRAM exposure

We remain more positive on DRAM-centric memory stocks and prefer Samsung (Key Call Buy), SK Hynix (Buy) and Micron (Buy) relative to WDC (Neutral). For semis caps, we continue to prefer memory-exposed players such as Lam Research and TEL (both Buy).

Figure 1: UBS memory semis stocks coverage

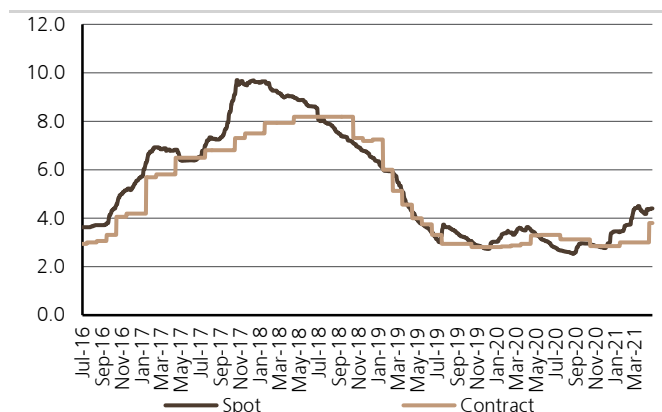
Company name	Ticker	Mkt Cap (US\$ mn)	Price	Price Target	21E PE	22E PE	21E PB	22E PB
Memory								
Micron Technology	MU.O	98,381	US\$88.06	US\$120	14.5	5.7	2.24	1.75
Samsung Electronics	005930.KS	439,681	Won81700	Won115000	14.8	9.7	2.06	1.76
SK Hynix	000660.KS	85,316	Won130000	Won195000	9.4	4.6	1.58	1.63
Western Digital	WDC.O	22,264	US\$71.13	US\$72	23.0	6.9	2.03	1.57

Source: UBS estimates. Note: Priced as of 29th April 2021.

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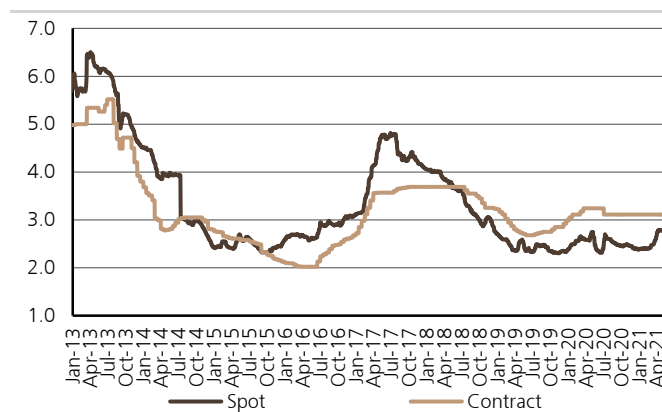
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Figure 2: DRAM spot vs. contract price (DDR4 8Gb, US\$)



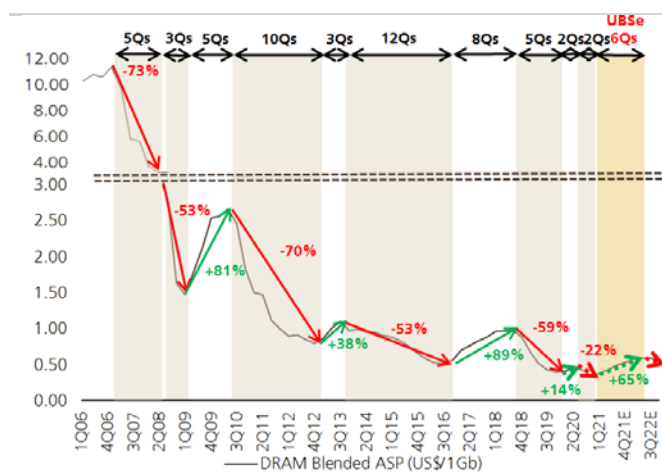
Source: DRAMeXchange

Figure 3: NAND spot vs. contract price (64Gb MLC, US\$)



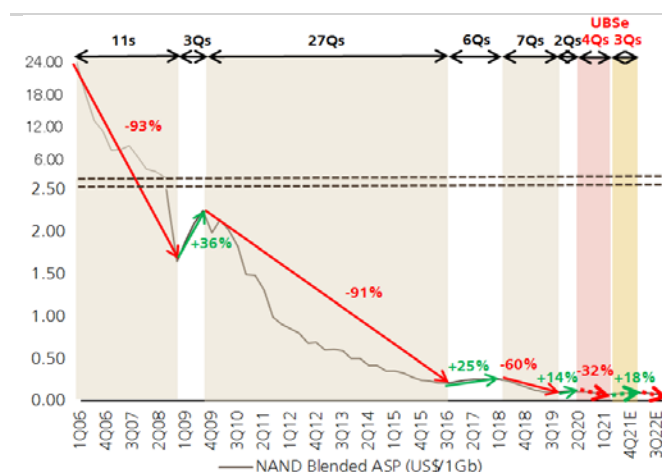
Source: DRAMeXchange

Figure 4: DRAM cycles in context



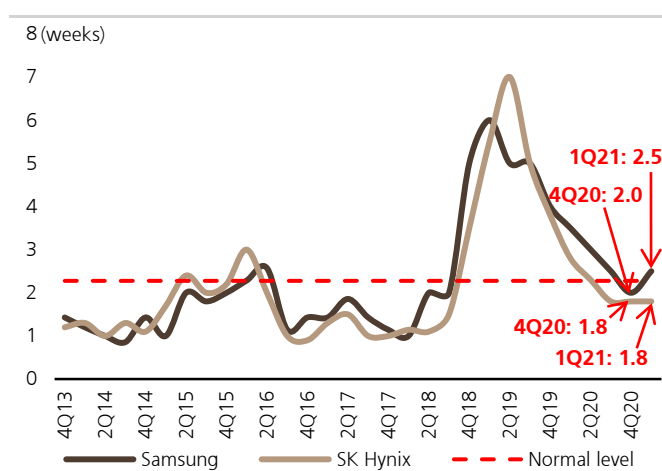
Source: Company data, UBS estimates

Figure 5: NAND cycles in context



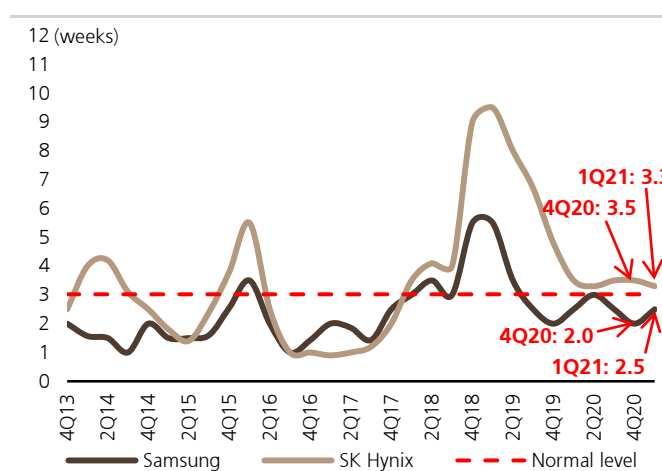
Source: Company data, UBS estimates

Figure 6: Samsung and SK Hynix – DRAM finished wafers and dies inventories



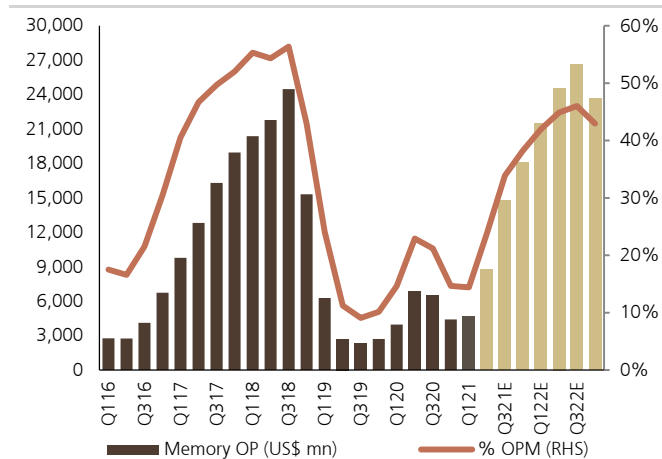
Source: Company data, UBS estimates

Figure 7: Samsung and SK Hynix – NAND finished wafers and dies inventories



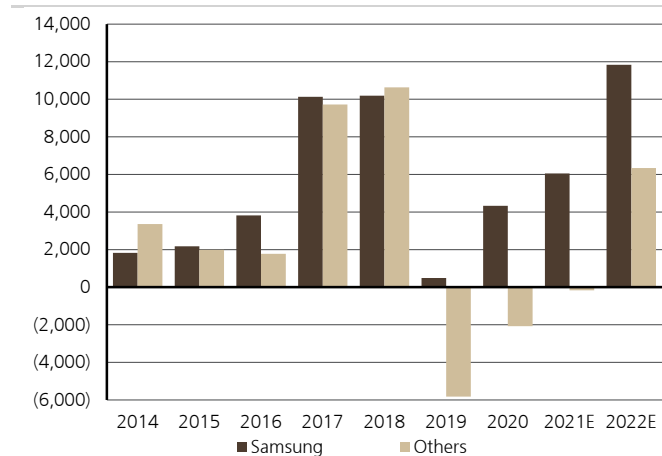
Source: Company data, UBS estimates

Figure 8: Memory industry OP and % OP margin



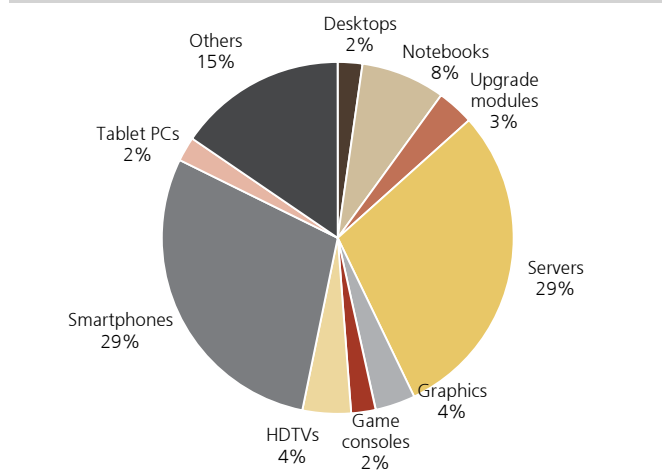
Source: Company data, UBS estimates

Figure 9: NAND OP – Samsung vs others (US\$m)



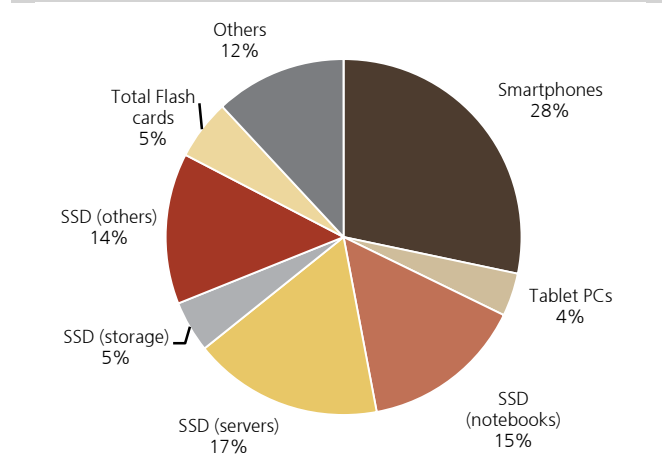
Source: Company data, UBS estimates

Figure 10: DRAM bit demand per application (2021E)



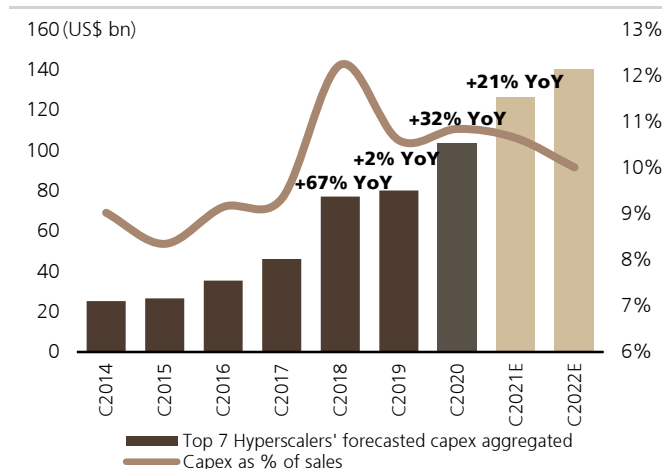
Source: Company data, UBS estimates

Figure 11: NAND bit demand per application (2021E)



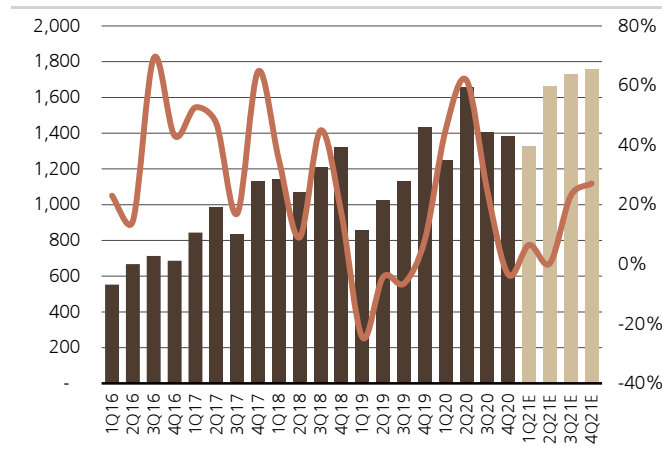
Source: Company data, UBS estimates

Figure 12: Top 7 Hyperscalers' capex forecasts aggregated (US\$bn) and total capital intensity (%)



Source: Company Data, UBS estimates – includes: Alibaba, Alphabet, Amazon, Baidu, Facebook, Microsoft, Tencent

Figure 13: Top 7 Hyperscalers' server procurement aggregate (K units) and YoY growth



Source: Dell'Oro Group, UBS estimates

SIGNPOSTS – DRAM

In order to see whether our thesis is playing out, here's what we'll be tracking:

DATA RELEASE / EVENT DATE		WHAT WE EXPECT
1H21	● DRAM inventory levels	DRAM inventories slightly elevated but no concern We estimate DRAM inventory levels close to 6 weeks for smartphone vendors. Hyperscale customers have been increasing DRAM inventories fearing shortages, and post some digestion, are now close to 8-10 weeks. We estimate PC DRAM inventories at 4-6 weeks. Samsung's finished products inventories stood at 2.5 weeks end of 1Q21 and SK Hynix below 2 weeks (forward).
'21/22	● Supply outlook	2021 DRAM capacity additions remaining limited so far We forecast Samsung to add 60k wpm DRAM capacity in P2 in '21. P3 should also have an initial DRAM qualification line installed by end '21 (10k wpm). We also believe Samsung is optimising output in P1 and Hwaseong. Upside is possible in 4Q21 for equipment installation at P2. We expect SK Hynix to install a qualification line in M16 (10-15k wpm) in 2Q21, before another 15-30k wpm in 2H21. SK Hynix has confirmed it will install more equipment in 4Q21 (both tech migration and M16 capacity). Micron is planning to keep net wafers start flat into '21.
'21	● Mobile DRAM demand (31% of total bit demand in 2021E)	Strong DRAM procurement from "OVX" – is this a risk? Oppo/Vivo/Xiaomi procurement is strong since mid-September 2020, but their smartphones builds have been as well. This implies limited DRAM inventory build for now. We believe that "OVX" is now indicating significant upside to procurement in 2Q/3Q21. Adjustments in 4Q21 are possible, but considering DRAM undersupply, likely limited in scope. We forecast 18% YoY mobile bit demand growth in '21 on the back of Sell-In (not procurement) ests. of smartphone units up 8% YoY. We forecast smartphone mobile DRAM content to grow from 4.6GB in 2020 to 5.1GB in 2021 and 5.6GB in 2022.
'21/22	● Server DRAM demand (29% of total bit demand in 2021E)	Steady server DRAM demand likely in 2021 and 2022 Since December '20, hyperscale server DRAM procurement has been firming up. We believe all top 4 US hyperscale customers are procuring steadily, with one large Cloud customer recently upsizing its orders. We expect a two-year or more steady server replacement cycle, with customers refreshing at different point in time in part in relation to their preference for Intel's Ice Lake (ramp late 2Q21E), Sapphire Rapids (ramp expected 2022), or AMD. We forecast hyperscale server unit procurement up 13% YoY in '21 and 16% in '22, and the mix shift towards them within the overall server market to support DRAM content growth. We hence forecast server DRAM end-demand to grow 33% YoY in bits in 2021, and 34% in 2022.
'21 /22	● China DRAM industry build-up	Significant challenges facing China DRAM efforts so far CXMT continues to invest and reached 45k wpm DRAM capacity '20 YE before ramping further to 100k wpm by '21 YE. We estimate wafer starts are currently closer to 27k wpm. We believe that 19nm production yields are well below normal levels. 17nm has also we believe been facing delays. Tsinghua Unigroup has announced ramping up DRAM in a new fab in Chongqing targeting mass production in '22. Due to US Entity List inclusion since October '18, Jinhua IC is not operating.

Source: UBS estimates

SIGNPOSTS – NAND Flash

In order to see whether our thesis is playing out, here's what we'll be tracking:

DATA RELEASE / EVENT DATE		WHAT WE EXPECT
1H21	● NAND inventory levels	NAND flash inventories remaining stable Downstream inventories are now largely stable at 3-5 weeks. Samsung NAND flash finished products inventories stood at 2.5 weeks at end of 1Q21 and SK Hynix (forward) 3-4 weeks. The inventory situation remains healthier than in 2018/1H19.
'21/22	● Supply outlook	Samsung steadily adding capacity Samsung aims to add c. 90k wpm of capacity for NAND flash in 2021 (equipment installation closer to 70k wpm), ramping in parallel P2 and Xi'an X2. Some upside is possible in 4Q21. SK Hynix will gradually add capacity in '21 for 128L (c. 20k wpm) in M15, and c. 10k for 176L. YMTC is planning to add 50k wpm capacity in Wuhan in '21, although the Chengdu project has been pushed out.
'21/22	● NAND flash demand	NAND flash demand showing upside in most verticals Stay-at-home PC demand continues to support solid state drive (SSD) demand and is robust into 1H21. UBS Evidence Lab Consumer PC survey indicated that 84% of respondents wanted a SSD in their PCs. PC demand could however slowdown in 2H21. Mobile demand continues to show upside for eMCP (China smartphone OEMs). But content growth is negatively impacted by NAND flash not being a priority spec for smartphones as 5G rolls out. Server flash arrays demand is now recovering, although enterprise storage remains for now more sluggish (we expect an acceleration in 2H21).
'21/22	● Samsung's NAND flash strategy	Set to drive NAND share regains & LT consolidation Samsung is set to regain lost market share in NAND flash in 2021. We believe Samsung is now more set in prioritising market share & pressuring competition, making use of its margins premium vs. peers, to ultimately contribute to possible industry consolidation. This may take some time, and is likely to lead Samsung to spend a-cyclically, ie. not to react too much to the pricing declines it is going to be a key contributor to.
'21/22	● China's NAND flash ramp	YMTC steadily ramping up over the next 3 years YMTC, being part of Tsinghua Unigroup, is well supported. Moreover, NAND Flash is inherently easier to manufacture than DRAM. As such, we believe YMTC alone could be more of a disruption into the NAND flash market than China's DRAM. We believe YMTC has achieved mature production yields for 64L, with 50k wpm capacity now installed in Fab A in Wuhan (wafer starts currently 36k). It is then set to start MP of 128L, and add 50k wpm capacity in the course of 2021, all 128L capable. If successful, by then, it will be more of a disruption on overall industry supply/demand (we est. 1.5% of NAND flash industry wafer and bits capacity by 4Q21). Beyond Fab A, construction for Fab B has begun. YMTC is also targeting completion of its first fab shell in Chengdu by year-end (mass production targeted by '22). We however believe that the Chengdu project has been delayed, pending technology transfer. YMTC targets to start mass production for 192L end of '21.

Source: UBS estimates

Figure 14: UBS DRAM supply/demand summary

	2019	2020	Q121	Q221E	Q321E	Q421E	2021E	Q122E	Q222E	Q322E	Q422E	2022E
Revenues (\$ mil)	62,475	64,152	16,793	19,979	23,196	25,189	85,158	28,259	31,177	33,954	33,801	127,190
% QoQ			9.3%	19.0%	16.1%	8.6%		12.2%	10.3%	8.9%	-0.4%	
% YoY	-37.1%	2.7%	14.5%	18.4%	34.4%	64.0%	32.7%	68.3%	56.0%	46.4%	34.2%	49.4%
Supply (Shipments Based) (M 1Gb)	125,950	154,767	44,952	46,103	47,369	46,762	185,187	49,030	52,516	57,194	59,933	218,673
% QoQ			5.1%	2.6%	2.7%	-1.3%		4.8%	7.1%	8.9%	4.8%	
% YoY	20.7%	22.9%	27.3%	25.6%	18.5%	9.3%	19.7%	9.1%	13.9%	20.7%	28.2%	18.1%
Demand (End Consumption) (M 1Gb)	127,093	156,786	42,321	45,522	48,641	54,927	191,411	50,573	52,541	56,983	64,066	224,162
% QoQ			-3.3%	7.6%	6.9%	12.9%		-7.9%	3.9%	8.5%	12.4%	
% YoY	19.6%	23.4%	20.5%	25.1%	17.1%	25.5%	22.1%	19.5%	15.4%	17.1%	16.6%	17.1%
Inventory adjustment	-3,900	-2,800	3,000	2,000	0	-7,200	-2,200	-800	400	400	-4,700	-4,700
Inventory Adj. Demand (M 1Gb)	123,193	153,986	45,321	47,522	48,641	47,727	189,211	49,773	52,941	57,383	59,366	219,462
% QoQ			9.3%	4.9%	2.4%	-1.9%		4.3%	6.4%	8.4%	3.5%	
% YoY	18.0%	25.0%	27.6%	26.8%	23.1%	15.1%	22.9%	9.8%	11.4%	18.0%	24.4%	16.0%
Wafer out (k wpm, 12" equi.)	1,315	1,341	1,393	1,413	1,434	1,469	1,427	1,518	1,545	1,567	1,576	1,551
% QoQ			1.1%	1.4%	1.5%	2.4%		3.3%	1.8%	1.4%	0.6%	
% YoY	4.7%	2.0%	6.7%	6.7%	5.6%	6.7%	6.4%	9.0%	9.4%	9.3%	7.3%	8.7%
% Sufficiency Ratio	2.2%	0.5%	-0.8%	-3.0%	-2.6%	-2.0%	-2.1%	-1.5%	-0.8%	-0.3%	1.0%	-0.4%
DRAM ASP (\$/Gb)	0.50	0.41	0.37	0.43	0.49	0.54	0.46	0.58	0.59	0.59	0.56	0.58
% QoQ			4.0%	16.0%	13.0%	10.0%		7.0%	3.0%	0.0%	-5.0%	
% YoY	-47.9%	-16.4%	-10.1%	-5.7%	13.5%	50.0%	10.9%	54.3%	37.0%	21.2%	4.7%	26.5%
PC DRAM ASP (\$/Gb)	0.43	0.38	0.38	0.45	0.52	0.57	0.48	0.61	0.63	0.63	0.58	0.61
% QoQ			4.2%	20.0%	15.0%	10.0%		7.0%	3.0%	0.0%	-7.0%	
% YoY	-55.8%	-11.5%	3.8%	9.4%	32.7%	58.1%	26.0%	62.4%	39.4%	21.2%	2.5%	27.6%

Source: Company data, UBS estimates

Figure 15: DRAM vendors' maker share in bit shipments

	2019	2020	Q121	Q221E	Q321E	Q421E	2021E	Q122E	Q222E	Q322E	Q422E	2022E
Samsung	45.6%	44.7%	44.7%	45.1%	45.4%	44.5%	44.9%	45.1%	45.3%	45.2%	44.7%	45.0%
SK Hynix	29.5%	29.3%	29.1%	28.9%	29.4%	30.5%	29.5%	29.1%	28.5%	28.9%	28.7%	28.8%
Micron	21.9%	22.7%	23.3%	22.9%	21.9%	21.7%	22.4%	22.6%	23.0%	22.8%	23.5%	23.0%
Nanya Tech	2.5%	2.7%	2.5%	2.4%	2.4%	2.3%	2.4%	2.2%	2.1%	2.0%	1.9%	2.0%
CXMT	0.0%	0.1%	0.1%	0.3%	0.5%	0.6%	0.4%	0.7%	0.8%	0.9%	1.0%	0.8%
Others	0.5%	0.5%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.3%	0.3%	0.4%
Total Supply	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: Gartner, Company data, UBS estimates

Figure 16: DRAM vendors bit shipments QoQ and YoY growth

	2019 YoY	2020 YoY	Q121 QoQ	Q221E QoQ	Q321E QoQ	Q421E QoQ	2021E YoY	Q122E QoQ	Q222E QoQ	Q322E QoQ	Q422E QoQ	2022E YoY
Samsung	22.5%	20.5%	5.0%	3.5%	3.6%	-3.4%	20.2%	6.3%	7.7%	8.6%	3.6%	18.4%
SK Hynix	21.0%	22.3%	4.0%	2.0%	4.5%	2.6%	20.2%	0.0%	4.9%	10.3%	4.1%	15.4%
Micron	18.1%	27.0%	7.0%	1.0%	-2.0%	-2.0%	18.4%	9.0%	9.0%	8.0%	8.0%	20.9%
Nanya Tech	10.4%	35.8%	4.0%	0.0%	2.0%	-5.0%	5.3%	-2.0%	3.0%	3.0%	0.0%	-1.2%
CXMT	79.7%	241.1%	39.9%	122.3%	75.0%	13.5%	444.6%	29.6%	15.1%	17.5%	17.7%	153.0%
Others	4.9%	11.7%	-5.4%	2.9%	2.8%	2.7%	2.1%	-2.6%	2.7%	2.6%	2.6%	5.5%
Bit supply Growth	20.7%	22.9%	5.1%	2.6%	2.7%	-1.3%	19.7%	4.8%	7.1%	8.9%	4.8%	18.1%

Source: Gartner, Company data, UBS estimates

Figure 17: DRAM vendors wafers out (k wpm, 12 inch equivalent)

	2019	2020	Q121	Q221E	Q321E	Q421E	2021E	Q122E	Q222E	Q322E	Q422E	2022E
Samsung	509	517	547	557	569	591	566	617	633	642	647	635
SK Hynix	351	352	356	357	361	367	360	378	388	397	399	390
Micron	332	340	340	340	340	340	340	340	340	340	340	340
Nanya Tech	72	73	73	73	73	73	73	73	73	73	73	73
CXMT	10	24	27	36	42	48	64	60	62	65	67	100
Other	50	50	50	50	50	50	50	50	50	50	50	50
Total	1,323	1,355	1,393	1,413	1,434	1,469	1,452	1,518	1,545	1,567	1,576	1,588
% YoY	4.7%	2.0%	6.7%	6.7%	5.6%	6.7%	6.4%	9.0%	9.4%	9.3%	7.3%	8.7%

Source: Gartner, Company data, UBS estimates

Figure 18: DRAM bit demand growth by application

	2019 YoY	2020 YoY	Q121 QoQ	Q221E QoQ	Q321E QoQ	Q421E QoQ	2021E YoY	Q122E QoQ	Q222E QoQ	Q322E QoQ	Q422E QoQ	2022E YoY
Total PC DRAM	4.1%	24.8%	-8.7%	0.7%	10.2%	-2.1%	9.4%	-9.7%	2.1%	13.8%	1.7%	1.9%
Desktops	13.5%	-11.6%	-11.4%	-0.6%	3.9%	2.2%	5.9%	-8.5%	4.3%	8.9%	4.7%	3.3%
Notebooks	15.2%	40.2%	-12.3%	-2.1%	13.3%	4.6%	16.0%	-12.6%	-0.8%	15.7%	9.3%	4.8%
Upgrade Modules	-16.8%	30.5%	2.9%	8.0%	7.9%	-18.9%	-1.5%	-2.5%	7.7%	12.8%	-18.0%	-5.7%
Servers	21.1%	41.8%	24.1%	19.7%	3.5%	12.8%	33.3%	6.9%	6.8%	4.5%	4.2%	34.3%
Graphics	17.8%	26.1%	5.2%	4.8%	4.8%	15.1%	41.5%	-10.6%	-8.7%	10.9%	15.5%	5.0%
Game Consoles	-14.3%	32.3%	20.2%	8.4%	14.3%	-1.5%	66.1%	-3.1%	2.8%	5.9%	-7.0%	7.5%
HDTVs	21.3%	23.7%	-27.2%	-1.4%	15.2%	38.1%	14.8%	-20.1%	0.2%	16.6%	26.6%	24.3%
Total Mobile DRAM	19.3%	7.4%	-16.9%	3.5%	10.5%	21.8%	17.6%	-22.3%	3.2%	11.8%	29.8%	10.9%
Smartphones	21.4%	5.6%	-17.4%	4.1%	10.8%	23.3%	18.4%	-22.6%	3.1%	12.3%	31.7%	12.4%
Apple	14.7%	25.0%	-30.6%	-26.6%	14.3%	67.3%	27.4%	-35.7%	-11.1%	31.3%	59.3%	11.5%
Samsung	36.3%	4.9%	29.2%	-16.8%	25.5%	-12.2%	18.8%	20.9%	3.2%	15.2%	-15.0%	23.7%
Non-Apple/Samsung	18.8%	2.6%	-24.4%	21.5%	6.1%	26.7%	16.5%	-29.3%	6.2%	7.5%	44.4%	9.2%
Tablet PCs	-4.8%	38.6%	-11.7%	-1.9%	6.2%	4.2%	9.0%	-18.1%	5.6%	5.0%	3.5%	-6.6%
Other	44.6%	31.0%	-0.4%	3.8%	1.2%	3.7%	17.9%	0.7%	4.1%	4.9%	4.3%	12.2%
Total Bit Demand	19.6%	23.4%	-3.3%	7.6%	6.9%	12.9%	22.1%	-7.9%	3.9%	8.5%	12.4%	17.1%

Source: Gartner, Company data, UBS estimates

Figure 19: DRAM content assumptions (MB/unit) by application

	2019	2020	Q121	Q221E	Q321E	Q421E	2021E	Q122E	Q222E	Q322E	Q422E	2022E
Total PC	6,373	7,351	7,936	8,076	8,282	8,497	8,200	8,642	8,814	9,083	9,420	9,001
% YoY	16%	15%	17%	12%	11%	9%	12%	9%	9%	10%	11%	10%
Desktops	5,904	6,562	7,063	7,213	7,413	7,613	7,324	7,713	7,913	8,113	8,313	8,022
Notebooks	7,160	8,236	8,790	8,940	9,090	9,240	9,023	9,440	9,640	9,940	10,240	9,835
Upgrade Modules	5,663	6,484	7,000	7,200	7,400	7,500	7,271	7,700	7,900	8,100	8,300	7,997
Servers	303,609	419,650	436,000	515,100	535,623	576,484	516,674	598,000	619,000	632,500	652,142	625,887
% YoY	25%	38%	7%	24%	23%	37%	23%	37%	20%	18%	13%	21%
Smartphones	4,148	4,643	4,943	5,010	5,182	5,189	5,091	5,390	5,408	5,666	5,689	5,555
% YoY	24%	12%	8%	11%	13%	7%	10%	9%	8%	9%	10%	9%
Apple	3,396	4,110	4,700	4,600	4,700	4,800	4,716	4,800	4,800	5,600	5,800	5,328
Samsung	3,820	4,672	4,871	4,659	5,138	4,974	4,917	5,775	5,512	5,877	5,529	5,676
Non-Apple/Samsung	4,422	4,761	5,050	5,200	5,300	5,350	5,241	5,400	5,500	5,600	5,700	5,569

Source: Gartner, Company data, UBS estimates

Figure 20: UBS NAND Flash supply/demand summary

	2019	2020	Q121	Q221E	Q321E	Q421E	2021E	Q122E	Q222E	Q322E	Q422E	2022E
Revenues (\$ mil)	40,095	49,454	11,883	13,006	15,915	17,381	58,184	18,065	18,918	19,420	17,631	74,033
% QoQ			3.0%	9.5%	22.4%	9.2%		3.9%	4.7%	2.7%	-9.2%	
% YoY	-26.1%	23.3%	-7.3%	6.7%	23.3%	50.7%	17.7%	52.0%	45.5%	22.0%	1.4%	27.2%
Supply (Shipments Based) (M 1GB)	365,829	469,276	145,943	152,129	169,237	181,198	648,506	188,335	207,602	236,794	252,916	885,647
% QoQ			10.8%	4.2%	11.2%	7.1%		3.9%	10.2%	14.1%	6.8%	
% YoY	42.1%	28.3%	35.5%	41.0%	38.9%	37.5%	38.2%	29.0%	36.5%	39.9%	39.6%	36.6%
Demand (End Consumption) (M 1GB)	362,785	460,343	136,263	146,627	167,489	196,813	647,191	187,188	199,053	226,452	268,127	880,820
% QoQ			0.7%	7.6%	14.2%	17.5%		-4.9%	6.3%	13.8%	18.4%	
% YoY	44.3%	26.9%	38.7%	37.4%	39.4%	45.5%	40.6%	37.4%	35.8%	35.2%	36.2%	36.1%
Inventory adjustment	-2,500	4,000	7,500	7,000	5,000	-15,000	4,500	1,000	6,500	5,800	-22,500	-9,200
Inventory Adj. Demand (M 1GB)	360,285	464,343	143,763	153,627	172,489	181,813	651,691	188,188	205,553	232,252	245,627	871,620
% QoQ			12.9%	6.9%	12.3%	5.4%		3.5%	9.2%	13.0%	5.8%	
% YoY	42.8%	28.9%	30.8%	44.0%	43.3%	42.8%	40.3%	30.9%	33.8%	34.6%	35.1%	33.7%
Wafer out (k wpm, 12" equi.)	1,451	1,507	1,558	1,572	1,599	1,645	1,593	1,689	1,727	1,759	1,791	1,741
% QoQ			0.5%	0.9%	1.7%	2.9%		2.6%	2.3%	1.9%	1.8%	
% YoY	-6.0%	3.8%	6.9%	5.4%	4.6%	6.2%	5.8%	8.4%	9.9%	10.0%	8.8%	9.3%
% Sufficiency Ratio	1.5%	1.1%	1.5%	-1.0%	-1.9%	-0.3%	-0.5%	0.1%	1.0%	2.0%	3.0%	1.6%
NAND ASP (\$/1GB)	0.11	0.11	0.08	0.09	0.09	0.10	0.09	0.10	0.09	0.08	0.07	0.08
% QoQ			-7.0%	5.0%	10.0%	2.0%		0.0%	-5.0%	-10.0%	-15.0%	
% YoY	-48.0%	-3.8%	-31.6%	-24.3%	-11.2%	9.6%	-14.9%	17.8%	6.6%	-12.8%	-27.3%	-6.8%

Source: Company data, UBS estimates

Figure 21: NAND Flash vendors market share in bit shipments

	2019	2020	Q121	Q221E	Q321E	Q421E	2021E	Q122E	Q222E	Q322E	Q422E	2022E
Samsung	46.3%	43.5%	44.2%	43.5%	43.9%	44.8%	44.1%	44.4%	44.9%	44.4%	44.8%	44.6%
Kioxia	15.5%	15.8%	14.9%	15.2%	15.0%	14.4%	14.9%	14.5%	14.1%	14.5%	13.7%	14.2%
Western Digital	12.0%	13.2%	12.0%	12.6%	12.5%	12.5%	12.4%	12.0%	11.5%	12.0%	11.8%	11.8%
SK Hynix	13.7%	15.2%	16.5%	15.8%	16.0%	15.7%	16.0%	15.8%	16.3%	16.2%	16.1%	16.1%
Micron	9.6%	9.0%	8.9%	9.2%	8.7%	8.4%	8.8%	8.8%	8.7%	8.3%	8.6%	8.6%
Intel	2.9%	2.9%	2.6%	2.7%	2.8%	2.7%	2.7%	2.6%	2.6%	2.5%	2.4%	2.5%
YMTC	0.1%	0.4%	0.9%	1.0%	1.0%	1.5%	1.1%	1.8%	2.0%	2.1%	2.5%	2.1%
Total Bit Supply	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: Gartner, Company data, UBS estimates

Figure 22: NAND Flash bit shipments QoQ and YoY growth

	2019 YoY	2020 YoY	Q121 QoQ	Q221E QoQ	Q321E QoQ	Q421E QoQ	2021E YoY	Q122E QoQ	Q222E QoQ	Q322E QoQ	Q422E QoQ	2022E YoY
Samsung	47.7%	20.5%	11.0%	2.5%	12.4%	9.2%	40.2%	3.1%	11.3%	12.8%	7.9%	38.2%
Kioxia	33.0%	31.0%	6.5%	6.5%	9.5%	2.5%	30.1%	5.0%	7.0%	17.0%	1.0%	30.0%
Western Digital	22.0%	40.9%	5.0%	10.0%	10.0%	7.0%	30.1%	0.0%	5.0%	20.0%	5.0%	30.3%
SK Hynix	50.9%	42.3%	21.0%	0.0%	12.5%	5.2%	45.4%	4.2%	13.8%	13.6%	6.1%	37.5%
Micron	40.1%	20.9%	8.0%	7.0%	6.0%	3.0%	34.1%	9.0%	9.0%	9.0%	10.0%	33.5%
Intel	74.8%	28.4%	1.0%	10.0%	15.0%	5.0%	30.1%	0.0%	8.0%	10.0%	5.0%	27.8%
YMTC	1228.0%	468.7%	44.5%	9.2%	22.1%	50.1%	262.5%	28.3%	21.8%	19.5%	29.0%	162.7%
Total Bit Supply	42.1%	28.3%	10.8%	4.2%	11.2%	7.1%	38.2%	3.9%	10.2%	14.1%	6.8%	36.6%

Source: Gartner, Company data, UBS estimates

Figure 23: NAND Flash vendors wafers out (k wpm, 12 inch equi.)

	2019	2020	Q121	Q221E	Q321E	Q421E	2021E	Q122E	Q222E	Q322E	Q422E	2022E
Samsung	464	486	528	543	563	590	556	615	631	640	644	632
Kioxia / WDC	495	550	550	550	550	550	550	550	550	550	550	550
SK Hynix	227	208	199	195	191	187	193	189	201	211	218	205
Micron	183	165	165	165	170	175	169	180	185	190	195	188
Intel	75	80	80	80	80	80	80	80	80	80	80	80
YMTC	13	25	36	39	46	63	68	75	80	88	104	110
Total	1,451	1,507	1,558	1,572	1,599	1,645	1,593	1,689	1,727	1,759	1,791	1,741
% YoY	-6.0%	3.8%	6.9%	5.4%	4.6%	6.2%	5.8%	8.4%	9.9%	10.0%	8.8%	9.3%

Source: Gartner, Company data, UBS estimates

Figure 24: NAND Flash bit demand growth by application

	2019 YoY	2020 YoY	Q121 QoQ	Q221E QoQ	Q321E QoQ	Q421E QoQ	2021E YoY	Q122E QoQ	Q222E QoQ	Q322E QoQ	Q422E QoQ	2022E YoY
Total Embedded	47.0%	29.5%	0.7%	7.6%	14.4%	18.1%	41.7%	-4.7%	6.3%	14.1%	19.1%	37.4%
Smartphones	40.6%	15.5%	-15.7%	3.4%	23.2%	30.9%	36.2%	-21.1%	5.2%	22.5%	37.7%	35.3%
iPhones	25.4%	18.5%	-30.0%	-25.0%	30.9%	63.8%	25.1%	-35.7%	-11.1%	43.5%	64.3%	25.3%
Samsung	82.5%	-7.4%	32.6%	-15.5%	44.5%	-13.5%	32.2%	19.1%	5.7%	30.2%	-15.8%	40.1%
Non- iPhone/Samsung	33.6%	25.8%	-20.3%	29.8%	13.6%	36.0%	43.5%	-24.5%	11.7%	12.6%	50.7%	38.1%
Tablet PCs	38.6%	85.3%	-9.8%	-10.1%	5.7%	11.8%	20.9%	-1.6%	-9.3%	5.2%	6.2%	3.6%
SSD-Total	52.0%	40.4%	13.1%	8.9%	11.4%	11.2%	45.9%	4.5%	8.5%	12.5%	11.9%	41.5%
SSD (notebooks)	23.6%	58.1%	-0.6%	4.6%	18.4%	9.0%	46.3%	-8.5%	3.3%	20.9%	13.6%	25.2%
SSD (servers)	34.6%	65.5%	25.7%	10.4%	6.4%	11.7%	37.1%	9.4%	9.2%	12.0%	10.0%	45.7%
SSD (storage)	20.8%	29.1%	-6.1%	4.0%	12.0%	20.1%	29.8%	-11.1%	4.0%	9.6%	9.0%	19.5%
SSD (others)	155.7%	5.6%	24.8%	13.4%	10.4%	10.0%	65.9%	18.1%	13.2%	7.4%	13.2%	61.3%
Total Flash cards	19.8%	-3.0%	1.0%	7.7%	12.0%	6.8%	24.3%	-8.3%	6.9%	6.6%	4.7%	13.8%
Mobile Phones - Flash cards	19.6%	-1.5%	36.0%	-2.6%	0.0%	-3.9%	19.0%	-6.8%	5.6%	4.8%	4.7%	-2.9%
Total Bit Demand	44.3%	26.9%	0.7%	7.6%	14.2%	17.5%	40.6%	-4.9%	6.3%	13.8%	18.4%	36.1%

Source: Gartner, Company data, UBS estimates

Figure 25: NAND Flash content assumptions (MB/unit) by application

	2019	2020	Q121	Q221E	Q321E	Q421E	2021E	Q122E	Q222E	Q322E	Q422E	2022E
Smartphones - Blended	80,067	101,845	111,759	118,417	134,522	150,276	129,919	153,483	159,504	176,049	196,294	173,461
% YoY	42%	27%	17%	27%	32%	33%	28%	37%	35%	31%	31%	34%
iPhones	159,965	183,522	193,331	193,331	226,099	226,099	206,674	226,099	226,099	288,358	308,019	262,327
Samsung	101,854	109,943	117,345	113,994	144,800	138,080	128,754	158,013	154,340	185,913	173,161	168,378
Non- iPhone/Samsung	65,186	86,066	100,000	110,000	120,000	130,000	116,693	140,000	150,000	160,000	170,000	156,853
SSD - Notebook PCs	279	319	350	359	414	472	399	462	457	481	514	481
% YoY	8%	14%	16%	12%	26%	48%	25%	32%	27%	16%	9%	20%
SSD- Servers	1,641	1,744	1,970	2,116	2,263	2,380	2,186	2,527	2,673	2,888	3,103	2,805
% YoY	13%	6%	17%	23%	28%	31%	25%	28%	26%	28%	30%	28%
SSD- Storage	3,674	4,137	4,701	4,994	5,287	5,580	5,161	5,726	5,873	6,019	6,166	5,955
% YoY	12%	13%	21%	24%	26%	27%	25%	22%	18%	14%	11%	15%

Source: Gartner, Company data, UBS estimates

Figure 26: UBS Server DRAM bottom-up model – 2017-2022E

		2017	2018	2019	2020	2021E	2022E
Total Server shipments (K unit)		11,451	12,951	12,585	12,915	13,977	15,498
	% YoY	2.5%	13.1%	-2.8%	2.6%	8.2%	10.9%
Traditional Enterprise		6,005	6,277	6,246	5,065	5,141	5,244
	% YoY	-8.6%	4.5%	-0.5%	-18.9%	1.5%	2.0%
Hyperscalers	% of total	52.4%	48.5%	49.6%	39.2%	36.8%	33.8%
		5,447	6,674	6,339	7,850	8,837	10,255
Light-load servers	% YoY	18.3%	22.5%	-5.0%	23.8%	12.6%	16.0%
	% of total	47.6%	51.5%	50.4%	60.8%	63.2%	66.2%
AI/ML/database servers		5,229	6,206	5,768	6,987	7,776	8,922
	% YoY	17.1%	18.7%	-7.1%	21.1%	11.3%	14.7%
	% of total	96.0%	93.0%	91.0%	89.0%	88.0%	87.0%
		218	467	571	864	1,060	1,333
	% YoY	57.8%	114.4%	22.1%	51.4%	22.8%	25.7%
	% of total	4.0%	7.0%	9.0%	11.0%	12.0%	13.0%
Avg. DRAM content (GB)		194	238	296	410	505	611
	% YoY	42.1%	22.5%	24.7%	38.2%	23.1%	21.1%
Traditional enterprise		174	190	237	310	360	430
	% YoY	34.7%	9.6%	24.3%	31.0%	16.1%	19.4%
Hyperscalers Blended		217	283	356	474	589	704
	% YoY	46.7%	30.3%	25.8%	33.4%	24.1%	19.6%
Light-load servers		205	262	326	435	539	652
	% YoY	46.4%	28.0%	24.4%	33.3%	23.9%	20.9%
AI/ML/database servers		500	550	650	790	950	1,050
	% YoY	25.0%	10.0%	18.2%	21.5%	20.3%	10.5%
Total server DRAM Demand (mn Gb)		17,789	24,641	29,850	42,341	56,420	75,783
	% YoY	45.6%	38.5%	21.1%	41.8%	33.3%	34.3%
Traditional enterprise		8,342	9,557	11,820	12,561	14,805	18,038
	% YoY	23.1%	14.6%	23.7%	6.3%	17.9%	21.8%
Hyperscalers		9,447	15,084	18,029	29,781	41,615	57,745
	% YoY	73.6%	59.7%	19.5%	65.2%	39.7%	38.8%
Light-load servers		8,575	13,028	15,062	24,324	33,556	46,547
	% YoY	71.5%	51.9%	15.6%	61.5%	38.0%	38.7%
AI/ML/database servers		871	2,055	2,967	5,456	8,059	11,198
	% YoY	97.2%	135.9%	44.3%	83.9%	47.7%	39.0%

Source: Dell'Oro Group, Gartner, Company data, UBS estimates

Figure 27: UBS Global Memory / Semicap valuation comparisons

		Current	Price	EV/Sales (x)			EV/EBITDA (x)			PE (x)			PBV (x)		
Company name	Rating	Price	Target	'21E	'22E	'23E	'21E	'22E	'23E	'21E	'22E	'23E	'21E	'22E	'23E
Memory															
Micron Technology	Buy	US\$88.06	US\$120	3.5	2.3	2.2	7.5	3.6	3.6	14.5	5.7	5.7	2.24	1.75	1.45
Samsung Elec.	Buy	Won81,700	Won115000	1.6	1.3	1.4	5.3	4.0	4.9	14.8	9.7	13.5	2.06	1.76	1.65
SK Hynix	Buy	Won130,000	Won195000	2.4	1.7	2.1	4.4	2.7	4.3	9.4	4.6	9.4	1.58	1.20	1.09
Western Digital	Neutral	US\$71.13	US\$72	1.2	1.0	1.0	6.7	3.4	3.6	23.0	6.9	7.5	2.03	1.57	1.34
Average				2.2	1.6	1.7	6.0	3.4	4.1	15.4	6.7	9.0	1.98	1.57	1.38
Semicap Equipment															
ASML	Neutral	€542.80	€525	12.2	10.9	10.5	33.4	28.5	26.7	41.9	35.0	32.9	15.32	12.92	11.03
ASM Pacific Tech.	Buy	HK\$122.00	HK\$155	2.4	2.1	1.9	11.2	10.0	9.1	20.3	18.1	16.4	3.51	3.19	2.90
Applied Materials	Neutral (CBE)	US\$135.39	US\$127	5.8	5.3	5.5	19.3	17.1	18.4	22.4	19.8	20.9	11.45	11.46	10.96
Disco	Neutral	¥36,900	¥37000	5.3	5.0	4.7	14.6	13.9	12.7	24.1	23.2	21.6	4.73	4.33	4.01
Eugene Technology	Buy	Won47,900	Won53000	2.7	1.8	1.5	10.9	6.7	5.6	15.4	9.9	9.1	3.59	2.67	2.09
Tokyo Electron	Buy	¥49,360	¥49000	4.7	4.4	4.2	16.6	15.2	14.3	25.6	23.7	22.8	6.96	6.07	5.36
KLA Corporation	Neutral	US\$326.36	US\$340	7.7	6.7	6.8	19.2	16.6	17.5	23.9	20.1	20.8	14.86	12.03	10.39
LAM Research	Buy	US\$640.97	US\$725	6.4	5.5	5.5	19.4	15.9	16.1	23.4	18.7	18.4	17.15	17.40	17.94
SCREEN Holdings	Buy	¥10,680	¥14200	1.2	1.1	1.1	8.4	7.4	6.8	16.0	14.2	13.7	2.21	1.98	1.79
Teradyne	Sell	US\$130.81	US\$100	6.1	6.5	6.1	18.7	21.9	20.3	25.8	31.3	26.9	9.33	9.86	10.59
Wonik IPS	Buy	Won50,400	Won60000	1.7	1.5	1.4	8.4	6.8	6.4	14.5	12.5	12.7	3.00	2.46	2.10
Average				5.1	4.6	4.5	16.4	14.6	14.0	23.8	21.7	20.7	8.37	7.67	7.20

Source: Company data, UBS estimates. Priced as of 29th April 2021

Valuation Method and Risk Statement

The DRAM and NAND markets are characterized by large fluctuations in supply, demand, and capital spending, which typically result in highly volatile ASPs and company earnings. The NAND flash market has also been characterized by rapid annual ASP/bit declines. If manufacturers fail to improve their cost structure in line with the decline in NAND ASP, we would expect margin deterioration.

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12-Month Rating	Definition	Coverage ¹	IB Services ²
Buy	FSR is > 6% above the MRA.	52%	31%
Neutral	FSR is between -6% and 6% of the MRA.	36%	28%
Sell	FSR is > 6% below the MRA.	12%	22%
Short-Term Rating	Definition	Coverage ³	IB Services ⁴
Buy	Stock price expected to rise within three months from the time the rating was assigned because of a specific catalyst or event.	<1%	<1%
Sell	Stock price expected to fall within three months from the time the rating was assigned because of a specific catalyst or event.	<1%	<1%

Source: UBS. Rating allocations are as of 31 March 2021.

1: Percentage of companies under coverage globally within the 12-month rating category.

2: Percentage of companies within the 12-month rating category for which investment banking (IB) services were provided within the past 12 months.

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Company Name	Reuters	12-month rating	Short-term rating	Price	Price date
Applied Materials Inc ^{16b, 20}	AMAT.O	Neutral (CBE)	N/A	US\$135.39	29 Apr 2021
ASM Pacific Technology ^{16a}	0522.HK	Buy	N/A	HK\$122.00	29 Apr 2021
ASML ^{16b}	ASML.AS	Neutral	N/A	€542.80	29 Apr 2021
Disco	6146.T	Neutral	N/A	¥36,900	28 Apr 2021
Eugene Technology	084370.KQ	Buy	N/A	Won47,900	29 Apr 2021
KLA Corporation ^{16b}	KLAC.O	Neutral	N/A	US\$326.36	29 Apr 2021
LAM Research Corp ^{16b}	LRCX.O	Buy	N/A	US\$640.97	29 Apr 2021
Micron Technology Inc ^{16b}	MU.O	Buy	N/A	US\$88.06	29 Apr 2021
Samsung Electronics	005930.KS	Buy	N/A	Won81,700	29 Apr 2021
SCREEN Holdings Co., Ltd.	7735.T	Buy	N/A	¥10,680	28 Apr 2021
SK Hynix	000660.KS	Buy	N/A	Won130,000	29 Apr 2021
Teradyne Inc ^{16b}	TER.O	Sell	N/A	US\$130.81	29 Apr 2021
Tokyo Electron	8035.T	Buy	N/A	¥49,360	28 Apr 2021
Western Digital Corp ^{13, 16b}	WDC.O	Neutral	N/A	US\$71.13	29 Apr 2021
Wonik IPS	240810.KQ	Buy	N/A	Won50,400	29 Apr 2021

Source: UBS. All prices as of local market close.

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