

Memory Semis Monthly

February '21 Edition: DRAM supply – restrained as well as constrained?

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Some upside to NAND contract pricing near term, DRAM moving upwards

We see some limited upside to NAND flash contract pricing in 1Q21, due to better-than-expected client (PC) solid state drive demand. We now forecast 1Q21 NAND contract ASPs to decline 8% QoQ (was -9%), and forecast -7% in 2Q21. We continue to forecast DRAM contract ASPs to increase 4% QoQ in 1Q21, with mobile 3%, server 4% and PC up 5%. We could see some upside in server DRAM ASPs should procurement move up again in 1Q. We continue to forecast DRAM blended contract ASPs to increase at least 10% QoQ in 2Q21.

DRAM capacity additions are not accelerating just yet

In spite of the recent upside in procurement from hyperscale server customers, we do not see evidence of a meaningful scaling up in DRAM capacity addition plans. We continue to forecast Samsung to add c. 60k wpm net wafer capacity 4Q20>4Q21E. Net of wafer capacity loss in existing lines (due to tech migration), we forecast SK Hynix' capacity addition to be limited to about 4k wpm 4Q20>4Q21E. We do not forecast net wafer capacity addition at Micron. Any changes to plans now would have a limited impact on output in 2021. In addition, we note that overall technology migration remains slower than in recent years. By 4Q21, we forecast 1x nm and above to still be 38% of Samsung's DRAM wafers out, and 31% for SK Hynix (most advanced mode being 1a nm). This continues to constrain supply growth.

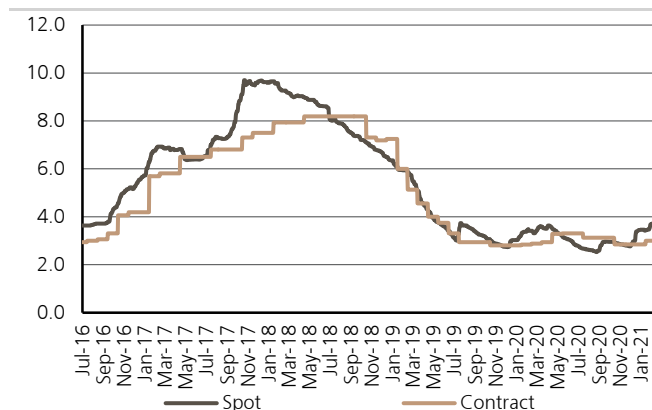
No meaningful changes in Samsung's NAND flash capacity addition plans

We have not seen evidence of a reduction in Samsung's NAND flash capacity addition plans for 2021, and continue to forecast c. 85k wpm net wafer capacity addition 4Q20>4Q21E. We note recent filings from Korean equipment vendors for Samsung's Xi'an, the larger ones being Wonik IPS (Won116bn – Jan 21st) and TES (Won27.6bn Jan 18th and Won51.9bn 27th Jan). We expect 176L mass production to start at Samsung by early 2Q21. Further, we believe Samsung is contemplating rolling out 22xL layers (dual stack) in 2022.

Continue to prefer DRAM-centric stocks and memory semiscap

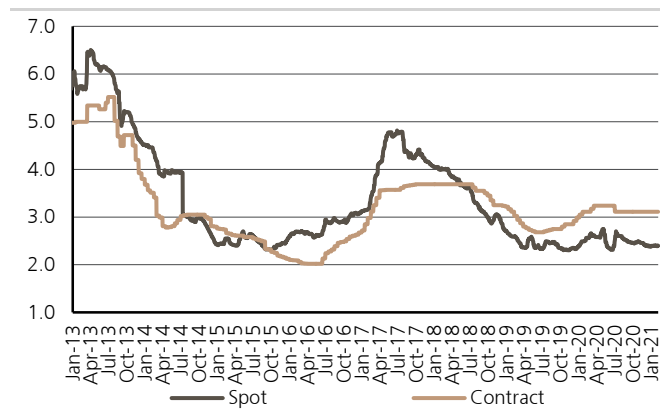
We continue to prefer Samsung (Key Call, Buy), SK Hynix and MU (both Buy) whereas we are more cautious on WDC (Neutral). Among semis caps, we continue to prefer memory-exposed players such as LRCX and TEL (both rated Buy).

Figure 1: DRAM spot vs. contract price (DDR4 8Gb, US\$)



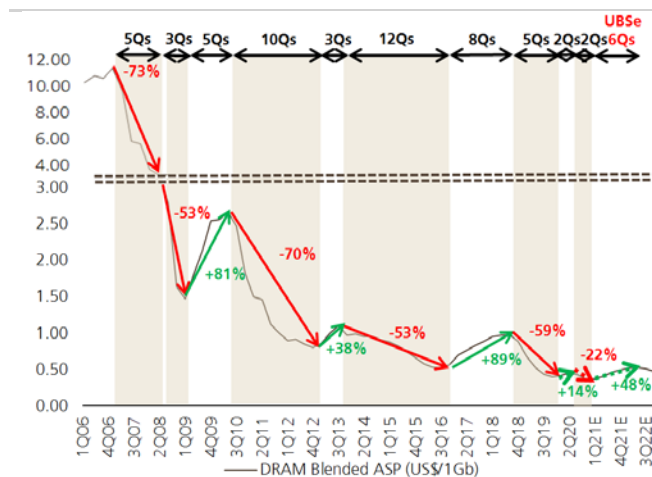
Source: DRAmEXchange

Figure 2: NAND spot vs. contract price (64Gb MLC, US\$)



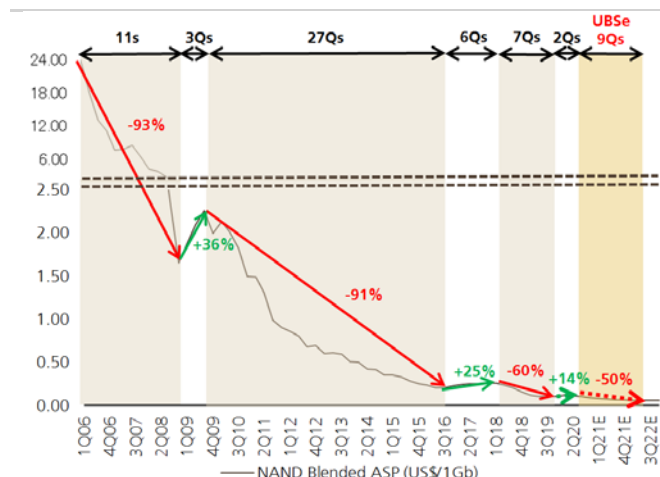
Source: DRAmEXchange

Figure 3: DRAM cycles in context



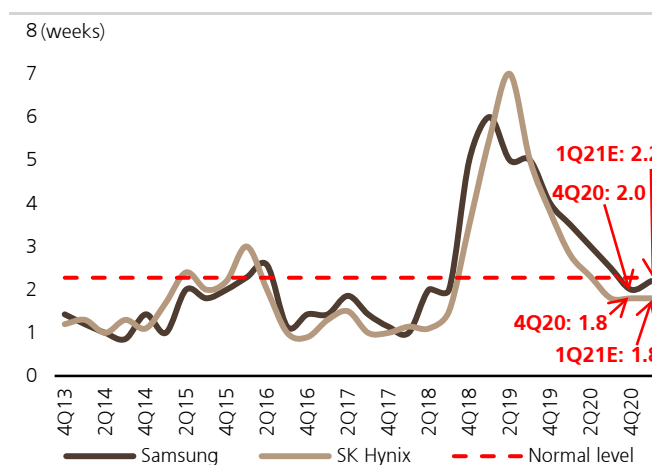
Source: Company data, UBS estimates

Figure 4: NAND cycles in context



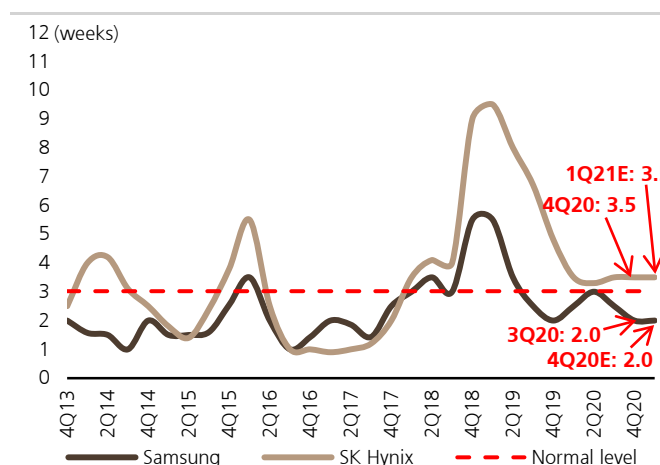
Source: Company data, UBS estimates

Figure 5: Samsung and SK Hynix – DRAM finished wafers and dies inventories



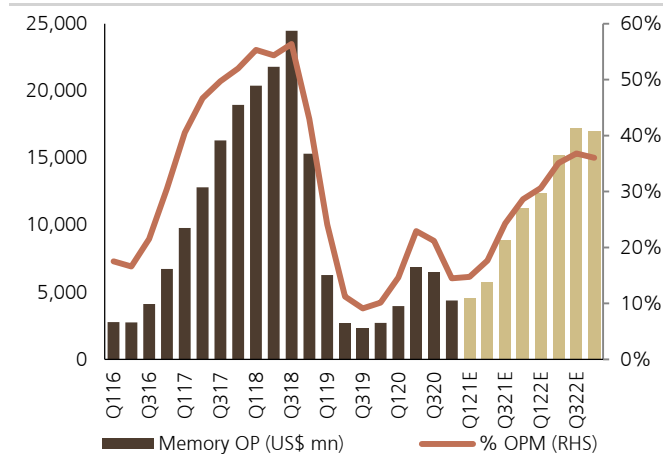
Source: Company data, UBS estimates

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



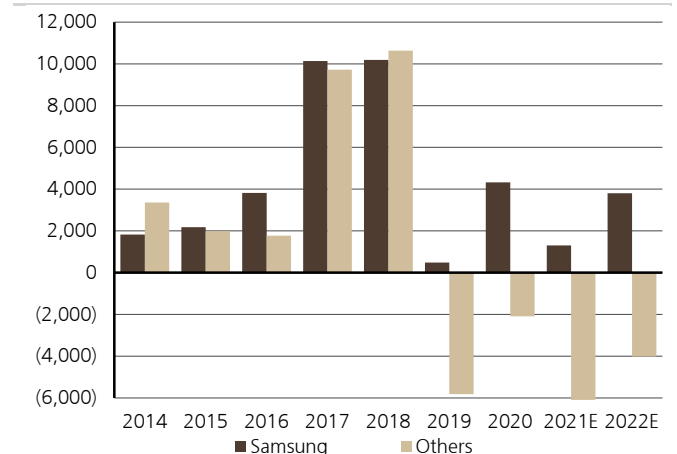
Source: Company data, UBS estimates

Figure 7: Memory industry OP and % OP margin



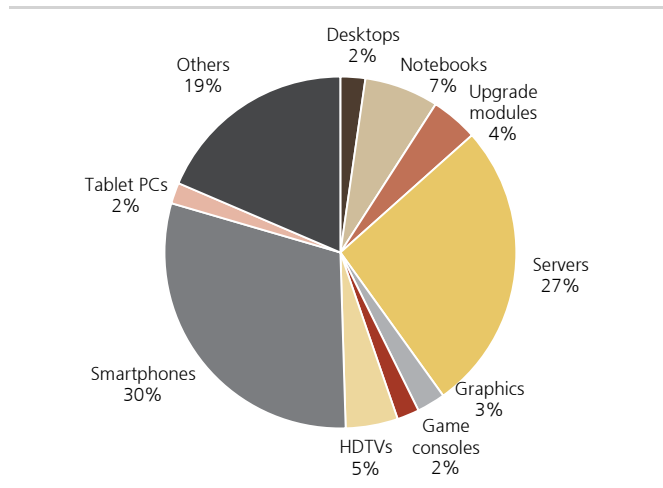
Source: Company data, UBS estimates

Figure 8: NAND OP – Samsung vs others (US\$m)



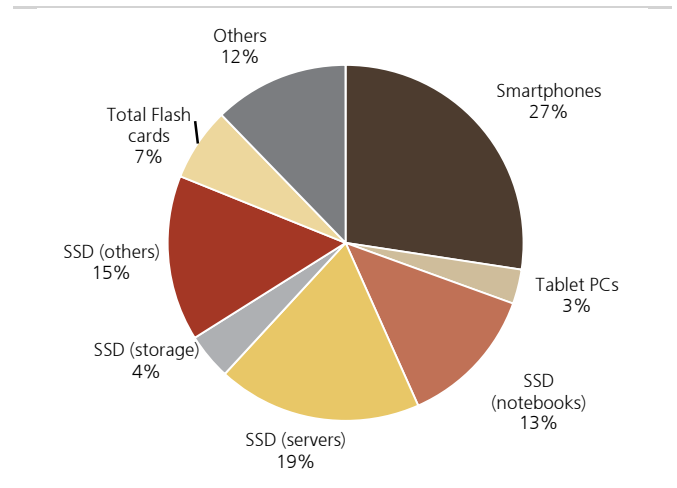
Source: Company data, UBS estimates

Figure 9: DRAM bit demand per application (2021E)



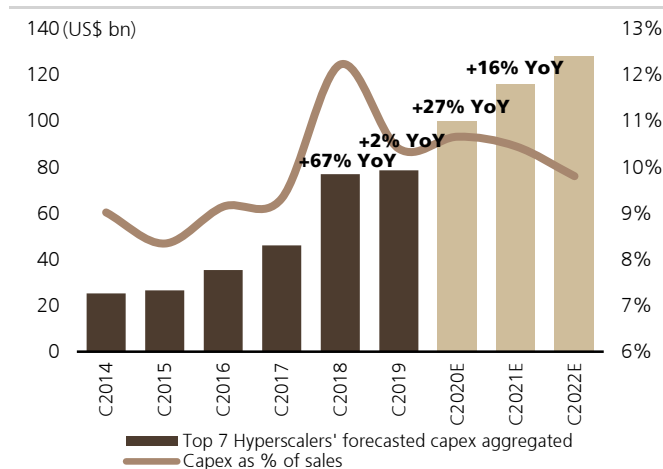
Source: Company data, UBS estimates

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



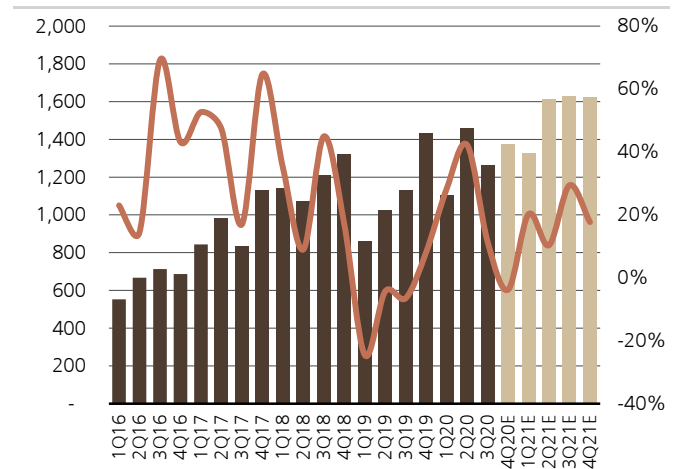
Source: Company data, UBS estimates

Figure 11: 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 12: 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 broadly in check We estimate DRAM inventory levels at 5-6 weeks for China smartphone OEMs (ex-Huawei). Apple/Samsung should be closer to 3-4 weeks. We believe most hyperscale customers' inventories are now closer to 6 weeks. Samsung's finished products inventories stood at 2 weeks end of 4Q20 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 2021. P3 should also have an initial DRAM qualification line installed by end '21 (10k wpm). We expect SK Hynix to install a qualification line in M16 (10-15k wpm) in 2Q21, before ramping further in 2H21 (15-30k wpm). Micron is planning to keep net wafers start flat into '21 even with new floor space available in Taichung by then.
'21	● Mobile DRAM demand (31% of total bit demand in 2021E)	Strong DRAM procurement from "OVX" – is this a risk? We believe Oppo/Vivo/Xiaomi have finalized long term agreements (LTAs) with DRAM makers for 2021, on concerns of a potential DRAM bottleneck as they seek to gain share from Huawei. "OVX" DRAM procurement is strong since mid-September, but their smartphones builds have been as well. This implies limited DRAM inventory build for now. That said, an overshooting compared to end-demand is not to be excluded progressing 2021. For now, we forecast 17% YoY mobile bit demand growth in '21 on the back of Sell-In (not procurement) ests of smartphone units up 6% YoY. We forecast smartphone mobile DRAM content to grow from 4.64GB in 2020 to 5.39GB in 2021 and 6.18GB in 2022.
'21/22	● Server DRAM demand (26% of total bit demand in 2021E)	Steady server DRAM demand likely in 2021 and 2022 We believe hyperscale customers have now signed LTAs with DRAM makers for 2021. We believe procurement estimates are firming up in 1H21, more so at this stage for US hyperscale customers rather than Chinese. We believe this is now the case for all top 4 US hyperscale customers for 1H21, including Microsoft which we believe carries higher DRAM inventories than peers. 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 server DRAM end-demand bit growth of 26/29% YoY in 2021 and 2022. We forecast hyperscale server unit procurement up 14% YoY in '21 and 16% in '22, and the mix shift towards them within the overall server market to support DRAM content growth.
'21 / 22	● China DRAM industry build-up (c. 1.5% industry supply by 2021E)	A long-term risk but gated by US/China Trade/IP dispute In the current state of technology restriction on semis manufacturing equipment sales to Jinhua IC, it is unlikely that it can ramp up pilot production. Conversely, a reversal of such band and a resolve on the IP dispute between Jinhua IC and Micron could present upside risk to supply over time. CXMT (the other China DRAM contender) continues to invest, but at a modest pace and we believe, is at 40k wpm DRAM capacity '20 YE before ramping further to 100k wpm by '21 YE. Tsinghua Unigroup has announced ramping up DRAM in a new fab in Chongqing targeting mass production in '22.

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
2H20	● NAND inventory levels	NAND flash inventories not too elevated Downstream inventories are now largely stable. Samsung NAND flash finished products inventories stood at 2 weeks at end of 4Q20 and SK Hynix (forward) 3.5 weeks. The inventory situation remains healthier than in 2018/1H19.
'21/22	● Supply outlook	Samsung steadily adding capacity Samsung aims to add c. 85k wpm of capacity for NAND flash in 2021. 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	PC SSD upside continues, more mixed elsewhere 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 81% of respondents wanted a SSD in their PCs. PC demand could however slowdown in 2H21. Mobile demand is showing some upside, similar to DRAM, on a set basis. But content growth is negatively impacted by NAND flash not being a priority spec for smartphones as 5G rolls out. Enterprise SSD and flash array demand should recover more in 2Q21, slightly lagging server DRAM recovery.
'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 3D NAND aspirations and US/China Trade/IP war	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 production targeted at Fab A by YE. Fab A is then set to start MP of 128L by YE, 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. 2% of NAND flash industry wafer and bits capacity by 4Q21). Beyond Fab A, construction for Fab B has begun with foundation work underway. 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 13: UBS DRAM supply/demand summary

	Q120	Q220	Q320	Q420	2020	Q121E	Q221E	Q321E	Q421E	2021E	Q122E	Q222E	Q322E	Q422E	2022E
Revenues (\$ mil)	14,667	16,869	17,255	15,362	64,152	15,919	18,204	21,848	24,299	80,270	25,835	28,110	29,345	28,458	111,748
% QoQ	-2.1%	15.0%	2.3%	-11.0%		3.6%	14.4%	20.0%	11.2%		6.3%	8.8%	4.4%	-3.0%	
% YoY	-12.8%	11.6%	10.9%	2.5%	2.7%	8.5%	7.9%	26.6%	58.2%	25.1%	62.3%	54.4%	34.3%	17.1%	39.2%
Supply (Shipments Based) (M 1Gb)	35,327	36,774	40,102	42,986	155,188	42,834	44,528	47,292	49,157	183,811	49,777	53,097	57,145	59,588	219,607
% QoQ	-4.9%	4.1%	9.0%	7.2%		-0.4%	4.0%	6.2%	3.9%		1.3%	6.7%	7.6%	4.3%	
% YoY	42.6%	28.3%	13.2%	15.7%	23.1%	21.2%	21.1%	17.9%	14.4%	18.4%	16.2%	19.2%	20.8%	21.2%	19.5%
Demand (End Consumption) (M 1Gb)	33,651	36,124	41,583	43,558	154,916	41,629	44,566	48,333	52,516	187,044	49,750	52,559	58,186	60,606	221,100
% QoQ	-10.3%	7.3%	15.1%	4.8%		-4.4%	7.1%	8.5%	8.7%		-5.3%	5.6%	10.7%	4.2%	
% YoY	33.9%	25.7%	16.5%	16.1%	21.9%	23.7%	23.4%	16.2%	20.6%	20.7%	19.5%	17.9%	20.4%	15.4%	18.2%
Inventory adjustment	1,900	2,200	-2,000	-2,000	100	1,500	900	200	-2,600	0	600	800	-1,400	-1,600	-1,600
Inventory Adj. Demand (M 1Gb)	35,551	38,324	39,583	41,558	155,016	43,129	45,466	48,533	49,916	187,044	50,350	53,359	56,786	59,006	219,500
% QoQ	-2.7%	7.8%	3.3%	5.0%		3.8%	5.4%	6.7%	2.9%		0.9%	6.0%	6.4%	3.9%	
% YoY	49.8%	39.6%	15.4%	13.8%	27.1%	21.3%	18.6%	22.6%	20.1%	20.7%	16.7%	17.4%	17.0%	18.2%	17.4%
Wafer out (k wpm, 12" equi.)	1,308	1,330	1,369	1,389	1,349	1,403	1,417	1,440	1,477	1,434	1,505	1,531	1,559	1,577	1,543
% QoQ	0.2%	1.7%	2.9%	1.5%		1.0%	1.0%	1.6%	2.6%		1.9%	1.7%	1.8%	1.2%	
% YoY	-1.6%	0.2%	4.5%	6.4%	2.4%	7.2%	6.5%	5.2%	6.3%	6.3%	7.3%	8.0%	8.3%	6.8%	7.6%
% Sufficiency Ratio	-0.6%	-4.0%	1.3%	3.4%	0.1%	-0.7%	-2.1%	-2.6%	-1.5%	-1.7%	-1.1%	-0.5%	0.6%	1.0%	0.0%
DRAM ASP (\$/Gb)	0.42	0.46	0.43	0.36	0.41	0.37	0.41	0.46	0.49	0.44	0.52	0.53	0.51	0.48	0.51
% QoQ	2.9%	10.5%	-6.2%	-16.9%		4.0%	10.0%	13.0%	7.0%		5.0%	2.0%	-3.0%	-7.0%	
% YoY	-38.9%	-13.0%	-2.0%	-11.4%	-16.6%	-10.5%	-10.9%	7.4%	38.3%	5.6%	39.7%	29.5%	11.2%	-3.4%	16.5%
PC DRAM ASP (\$/Gb)	0.36	0.41	0.39	0.36	0.38	0.37	0.42	0.47	0.50	0.44	0.52	0.52	0.50	0.45	0.49
% QoQ	3.2%	13.8%	-5.2%	-7.7%		3.0%	12.0%	13.0%	7.0%		4.0%	0.0%	-5.0%	-10.0%	
% YoY	-43.6%	-8.6%	11.4%	2.9%	-11.5%	2.6%	1.0%	20.3%	39.5%	16.3%	40.8%	25.7%	5.7%	-11.1%	12.0%

Source: Company data, UBS estimates

Figure 14: DRAM vendors' maker share in bit shipments

	Q120	Q220	Q320	Q420	2020	Q121E	Q221E	Q321E	Q421E	2021E	Q122E	Q222E	Q322E	Q422E	2022E
Samsung	45.7%	45.0%	43.3%	44.5%	44.6%	43.5%	44.3%	44.8%	45.0%	44.4%	44.3%	44.9%	44.1%	43.0%	44.1%
SK Hynix	30.2%	29.6%	28.2%	29.2%	29.3%	29.3%	28.7%	28.5%	28.2%	28.7%	27.4%	26.9%	28.2%	29.1%	28.0%
Micron	20.6%	21.8%	25.0%	22.7%	22.6%	23.5%	23.1%	22.6%	22.4%	22.9%	23.4%	23.1%	22.5%	22.7%	22.9%
Nanya Tech	2.9%	2.9%	2.6%	2.5%	2.7%	2.4%	2.4%	2.3%	2.2%	2.3%	2.1%	2.0%	1.9%	1.8%	2.0%
CXMT (Innotron)	0.1%	0.2%	0.4%	0.6%	0.4%	0.9%	1.1%	1.4%	1.9%	1.4%	2.4%	2.8%	2.9%	3.1%	2.8%
Others	0.5%	0.5%	0.4%	0.4%	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%	100%	100%	100%

Source: Gartner, Company data, UBS estimates

Figure 15: DRAM vendors bit shipments QoQ and YoY growth

	Q120 QoQ	Q220 QoQ	Q320 QoQ	Q420 QoQ	2020 YoY	Q121E QoQ	Q221E QoQ	Q321E QoQ	Q421E QoQ	2021E YoY	Q122E QoQ	Q222E QoQ	Q322E QoQ	Q422E QoQ	2022E YoY
Samsung	-5.0%	2.4%	5.0%	10.0%	20.5%	-2.5%	5.7%	7.4%	4.4%	18.0%	-0.2%	7.9%	5.9%	1.6%	18.5%
SK Hynix	-4.0%	2.0%	4.0%	11.0%	22.3%	0.0%	1.8%	5.5%	3.0%	16.0%	-1.6%	4.7%	12.8%	7.5%	16.6%
Micron	-8.0%	10.0%	25.0%	-2.3%	27.0%	3.0%	2.0%	4.0%	3.0%	19.8%	6.0%	5.0%	5.0%	5.0%	19.6%
Nanya Tech	12.0%	5.6%	-2.5%	2.0%	35.8%	-5.0%	5.0%	2.0%	-3.0%	0.3%	-2.0%	3.0%	3.0%	0.0%	1.6%
CXMT (Innotron)	2.1%	153.4%	89.8%	60.2%	411.8%	37.0%	39.8%	33.7%	35.7%	347.7%	26.3%	26.3%	11.1%	11.1%	146.0%
Others	-5.4%	0.0%	2.9%	2.8%	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	-4.9%	4.1%	9.0%	7.2%	23.1%	-0.4%	4.0%	6.2%	3.9%	18.4%	1.3%	6.7%	7.6%	4.3%	19.5%

Source: Gartner, Company data, UBS estimates

Figure 16: DRAM vendors wafers out (k wpm, 12 inch equivalent)

	Q120	Q220	Q320	Q420	2020	Q121E	Q221E	Q321E	Q421E	2021E	Q122E	Q222E	Q322E	Q422E	2022E
Samsung	495	508	530	535	517	547	557	569	588	565	603	608	609	608	607
SK Hynix	345	348	355	359	352	356	352	356	362	356	363	370	392	407	383
Micron	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340
Nanya Tech	73	73	73	73	73	73	73	73	73	73	73	73	73	73	73
CXMT (Innotron)	5	12	21	32	25	38	45	53	64	65	77	90	95	100	98
Other	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Total	1,308	1,330	1,369	1,389	1,356	1,403	1,417	1,440	1,477	1,449	1,505	1,531	1,559	1,577	1,550
% YoY	-1.6%	0.2%	4.5%	6.4%	2.4%	7.2%	6.5%	5.2%	6.3%	6.3%	7.3%	8.0%	8.3%	6.8%	7.6%

Source: Gartner, Company data, UBS estimates

Figure 17: DRAM bit demand growth by application

	Q120 QoQ	Q220 QoQ	Q320 QoQ	Q420 QoQ	2020 YoY	Q121E QoQ	Q221E QoQ	Q321E QoQ	Q421E QoQ	2021E YoY	Q122E QoQ	Q222E QoQ	Q322E QoQ	Q422E QoQ	2022E YoY
Total PC DRAM	-16.3%	20.7%	12.3%	4.2%	24.4%	-12.8%	5.4%	10.3%	5.0%	9.8%	-11.2%	3.4%	8.7%	1.6%	5.1%
Desktops	-21.8%	-10.4%	16.1%	-11.2%	-18.8%	2.0%	5.2%	7.9%	3.8%	6.5%	-9.8%	3.4%	5.8%	4.8%	4.1%
Notebooks	-25.6%	54.5%	16.1%	16.3%	43.2%	-23.4%	1.6%	6.6%	10.8%	6.9%	-13.5%	3.9%	7.3%	15.4%	7.2%
Upgrade Modules	3.3%	-1.9%	3.1%	-12.4%	30.5%	8.1%	13.1%	18.2%	-3.7%	17.4%	-7.6%	2.6%	12.8%	-23.1%	1.9%
Servers	-4.8%	-1.4%	-2.1%	2.0%	25.9%	10.3%	14.3%	5.9%	11.7%	29.9%	3.4%	7.0%	7.1%	0.7%	29.8%
Graphics	-17.9%	13.7%	21.6%	-9.3%	18.7%	-21.5%	11.4%	24.9%	2.9%	1.8%	-13.3%	8.2%	22.9%	-3.1%	18.1%
Game Consoles	-8.1%	36.2%	44.1%	-8.5%	36.3%	27.4%	6.3%	13.9%	-1.4%	66.9%	-25.8%	18.7%	19.4%	-17.5%	-5.4%
HDTVs	-28.3%	3.4%	45.0%	16.9%	21.3%	-24.7%	-1.4%	15.2%	38.1%	17.0%	-20.1%	0.2%	16.6%	26.6%	24.3%
Total Mobile DRAM	-24.4%	1.1%	27.4%	5.3%	4.5%	-9.7%	4.6%	10.8%	6.8%	16.8%	-8.7%	5.2%	16.7%	7.0%	16.9%
Smartphones	-25.8%	-0.4%	29.0%	5.4%	2.8%	-8.7%	4.7%	11.4%	7.3%	19.1%	-8.8%	5.3%	17.4%	6.7%	17.8%
Apple	-39.5%	-11.4%	10.8%	146.0%	24.9%	-33.7%	-26.4%	15.1%	64.7%	20.6%	-37.1%	-4.5%	22.2%	60.8%	10.2%
Samsung	0.6%	-16.5%	58.1%	-23.5%	4.9%	27.7%	-5.3%	14.3%	-17.8%	21.3%	26.4%	4.5%	14.0%	-14.2%	22.3%
Non-Apple/Samsung	-29.2%	7.2%	24.0%	-4.2%	-1.5%	-9.7%	16.6%	9.9%	5.6%	18.1%	-10.1%	7.4%	17.8%	4.4%	18.1%
Tablet PCs	-3.7%	20.4%	11.9%	1.6%	33.3%	-21.4%	4.0%	1.8%	-5.1%	-10.2%	-4.4%	5.8%	4.7%	8.7%	2.2%
Other	42.0%	19.8%	12.2%	8.1%	55.5%	0.1%	4.6%	3.1%	5.8%	24.2%	0.1%	5.5%	4.8%	4.3%	15.5%
Total Bit Demand	-10.3%	7.3%	15.1%	4.8%	21.9%	-4.4%	7.1%	8.5%	8.7%	20.7%	-5.3%	5.6%	10.7%	4.2%	18.2%

Source: Gartner, Company data, UBS estimates

Figure 18: DRAM content assumptions (MB/unit) by application

	Q120	Q220	Q320	Q420	2020	Q121E	Q221E	Q321E	Q421E	2021E	Q122E	Q222E	Q322E	Q422E	2022E
Total PC	6,826	7,201	7,491	7,872	7,376	7,907	8,041	8,191	8,382	8,140	8,540	8,747	8,980	9,367	8,914
% YoY	14%	16%	15%	17%	16%	16%	12%	9%	6%	10%	8%	9%	10%	12%	10%
Desktops	6,298	6,400	6,632	6,868	6,541	7,068	7,218	7,418	7,618	7,338	7,718	7,918	8,118	8,318	8,023
Notebooks	7,799	8,013	8,323	8,623	8,253	8,773	8,923	9,073	9,223	9,006	9,423	9,623	9,923	10,223	9,817
Upgrade Modules	6,200	6,400	6,600	6,800	6,484	7,000	7,200	7,400	7,500	7,291	7,700	7,900	8,100	8,300	7,989
Servers	353,000	359,500	373,250	386,967	367,632	394,000	436,000	450,000	498,354	445,485	508,000	518,000	533,000	548,832	527,341
% YoY	63%	37%	9%	2%	21%	12%	21%	21%	29%	21%	29%	19%	18%	10%	18%
Smartphones	4,576	4,516	4,585	4,830	4,637	5,006	5,101	5,305	5,387	5,209	5,699	5,786	6,105	6,179	5,958
% YoY	18%	11%	8%	11%	12%	9%	13%	16%	12%	12%	14%	13%	15%	15%	14%
Apple	3,769	3,560	3,728	4,742	4,105	4,700	4,600	4,700	4,800	4,715	4,800	4,800	5,600	5,800	5,322
Samsung	4,891	4,389	4,686	4,696	4,672	4,987	4,799	5,097	4,956	4,963	5,718	5,514	5,837	5,538	5,655
Non-Apple/Samsung	4,660	4,750	4,700	4,900	4,756	5,100	5,300	5,500	5,700	5,415	5,900	6,100	6,300	6,500	6,217

Source: Gartner, Company data, UBS estimates

Figure 19: UBS NAND Flash supply/demand summary

	Q120	Q220	Q320	Q420	2020	Q121E	Q221E	Q321E	Q421E	2021E	Q122E	Q222E	Q322E	Q422E	2022E
Revenues (\$ mil)	12,820	12,188	12,909	11,537	49,454	11,566	11,159	11,348	11,570	45,642	11,302	12,258	14,051	15,344	52,955
% QoQ	12.5%	-4.9%	5.9%	-10.6%		0.2%	-3.5%	1.7%	2.0%		-2.3%	8.5%	14.6%	9.2%	
% YoY	38.1%	30.8%	27.8%	1.2%	23.3%	-9.8%	-8.4%	-12.1%	0.3%	-7.7%	-2.3%	9.9%	23.8%	32.6%	16.0%
Supply (Shipments Based) (M 1GB)	107,946	107,844	121,860	134,532	472,182	146,595	152,086	166,300	178,491	643,472	183,534	205,212	235,214	251,825	875,785
% QoQ	1.2%	-0.1%	13.0%	10.4%		9.0%	3.7%	9.3%	7.3%		2.8%	11.8%	14.6%	7.1%	
% YoY	44.4%	23.7%	25.4%	26.2%	29.1%	35.8%	41.0%	36.5%	32.7%	36.3%	25.2%	34.9%	41.4%	41.1%	36.1%
Demand (End Consumption) (M 1GB)	96,395	104,293	121,005	136,619	458,313	131,477	143,102	162,364	182,039	618,982	177,513	196,538	226,047	253,362	853,460
% QoQ	-11.9%	8.2%	16.0%	12.9%		-3.8%	8.8%	13.5%	12.1%		-2.5%	10.7%	15.0%	12.1%	
% YoY	26.8%	26.7%	27.4%	24.9%	26.4%	36.4%	37.2%	34.2%	33.2%	35.1%	35.0%	37.3%	39.2%	39.2%	37.9%
Inventory adjustment	13,800	2,500	-900	-7,100	8,300	12,400	6,500	1,100	-5,500	14,500	4,000	7,000	9,200	-1,000	19,200
Inventory Adj. Demand (M 1GB)	110,195	106,793	120,105	129,519	466,613	143,877	149,602	163,464	176,539	633,482	181,513	203,538	235,247	252,362	872,660
% QoQ	2.7%	-3.1%	12.5%	7.8%		11.1%	4.0%	9.3%	8.0%		2.8%	12.1%	15.6%	7.3%	
% YoY	54.0%	25.8%	24.2%	20.7%	29.5%	30.6%	40.1%	36.1%	36.3%	35.8%	26.2%	36.1%	43.9%	42.9%	37.8%
Wafer out (k wpm, 12" equi.)	1,458	1,492	1,498	1,513	1,490	1,491	1,585	1,554	1,622	1,563	1,676	1,730	1,831	1,892	1,782
% QoQ	6.8%	2.3%	0.4%	1.0%		-1.5%	6.3%	-2.0%	4.3%		3.4%	3.2%	5.8%	3.3%	
% YoY	-8.9%	2.2%	8.6%	10.8%	2.7%	2.3%	6.3%	3.7%	7.2%	4.9%	12.4%	9.1%	17.8%	16.7%	14.0%
% Sufficiency Ratio	-2.0%	1.0%	1.5%	3.9%	1.2%	1.9%	1.7%	1.7%	1.1%	1.6%	1.1%	0.8%	0.0%	-0.2%	0.4%
NAND ASP (\$/1GB)	0.12	0.11	0.11	0.09	0.10	0.08	0.07	0.07	0.06	0.07	0.06	0.06	0.06	0.06	0.06
% QoQ	11.1%	-4.8%	-6.3%	-19.1%		-8.0%	-7.0%	-7.0%	-5.0%		-5.0%	-3.0%	0.0%	2.0%	
% YoY	-4.3%	5.8%	1.9%	-19.8%	-4.4%	-33.6%	-35.1%	-35.6%	-24.4%	-32.3%	-21.9%	-18.6%	-12.5%	-6.0%	-14.8%

Source: Company data, UBS estimates

Figure 20: NAND Flash vendors market share in bit shipments

	Q120	Q220	Q320	Q420	2020	Q121E	Q221E	Q321E	Q421E	2021E	Q122E	Q222E	Q322E	Q422E	2022E
Samsung	43.7%	42.2%	43.7%	43.2%	43.2%	44.1%	42.9%	42.5%	43.9%	43.3%	44.1%	44.9%	43.8%	43.3%	44.0%
Kioxia (Toshiba Memory)	15.9%	15.1%	16.7%	17.0%	16.2%	17.1%	15.7%	15.8%	14.7%	15.8%	14.3%	14.1%	15.3%	15.0%	14.7%
Western Digital (SanDisk)	13.2%	14.3%	12.8%	12.4%	13.1%	11.9%	12.6%	12.7%	12.7%	12.5%	12.3%	11.6%	12.1%	11.9%	12.0%
SK Hynix	14.9%	15.7%	15.1%	14.8%	15.1%	14.2%	15.5%	15.7%	15.2%	15.2%	15.0%	15.2%	14.9%	15.2%	15.1%
Micron	9.3%	9.5%	8.4%	9.0%	9.0%	8.9%	9.2%	8.9%	8.7%	8.9%	9.2%	9.0%	8.5%	8.7%	8.8%
Intel	2.8%	3.0%	2.9%	2.7%	2.8%	2.5%	2.7%	2.8%	2.8%	2.7%	2.7%	2.6%	2.5%	2.5%	2.6%
YMTC	0.2%	0.3%	0.4%	1.0%	0.5%	1.2%	1.4%	1.6%	2.0%	1.6%	2.3%	2.7%	2.8%	3.4%	2.9%
Total Bit Supply	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: Gartner, Company data, UBS estimates

Figure 21: NAND Flash bit shipments QoQ and YoY growth

	Q120 QoQ	Q220 QoQ	Q320 QoQ	Q420 QoQ	2020 YoY	Q121E QoQ	Q221E QoQ	Q321E QoQ	Q421E QoQ	2021E YoY	Q122E QoQ	Q222E QoQ	Q322E QoQ	Q422E QoQ	2022E YoY
Samsung	-4.0%	-3.5%	17.1%	9.0%	20.5%	11.1%	1.1%	8.2%	10.9%	36.7%	3.4%	13.7%	11.8%	5.8%	38.1%
Kioxia (Toshiba Memory)	4.0%	-5.0%	25.0%	12.0%	35.5%	10.0%	-5.0%	10.0%	0.0%	32.3%	0.0%	10.0%	25.0%	5.0%	27.2%
Western Digital (SanDisk)	7.0%	8.0%	1.0%	7.0%	40.9%	5.0%	10.0%	10.0%	7.0%	30.1%	0.0%	5.0%	20.0%	5.0%	30.3%
SK Hynix	12.0%	5.0%	9.0%	8.0%	42.3%	5.0%	12.8%	10.8%	4.1%	37.0%	1.5%	13.0%	12.4%	9.5%	35.2%
Micron	-1.0%	1.9%	0.0%	18.3%	20.9%	8.0%	7.0%	6.0%	5.0%	34.8%	9.0%	9.0%	9.0%	9.0%	35.1%
Intel	1.0%	5.0%	10.0%	5.0%	28.4%	1.0%	10.0%	15.0%	5.0%	30.1%	0.0%	8.0%	10.0%	5.0%	27.8%
YMTC	42.2%	54.4%	46.4%	169.5%	572.0%	35.7%	18.2%	27.2%	35.4%	334.2%	16.8%	31.4%	19.5%	28.8%	145.6%
Total Bit Supply	1.2%	-0.1%	13.0%	10.4%	29.1%	9.0%	3.7%	9.3%	7.3%	36.3%	2.8%	11.8%	14.6%	7.1%	36.1%

Source: Gartner, Company data, UBS estimates

Figure 22: NAND Flash vendors wafers out (k wpm, 12 inch equi.)

	Q120	Q220	Q320	Q420	2020	Q121E	Q221E	Q321E	Q421E	2021E	Q122E	Q222E	Q322E	Q422E	2022E
Samsung	439	469	510	525	486	527	541	560	589	554	610	616	623	629	619
Western Digital / Kioxia	550	550	520	500	530	470	550	490	510	505	530	550	550	570	550
SK Hynix	215	209	206	203	208	199	195	191	187	193	187	191	196	208	195
Micron	162	170	165	165	165	165	165	170	175	169	180	185	265	270	225
Intel	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
YMTC	12	14	17	40	25	50	54	63	81	68	90	108	117	135	125
Total	1,458	1,492	1,498	1,513	1,490	1,491	1,585	1,554	1,622	1,563	1,676	1,730	1,831	1,892	1,782
% YoY	-8.9%	2.2%	8.6%	10.8%	2.7%	2.3%	6.3%	3.7%	7.2%	4.9%	12.4%	9.1%	17.8%	16.7%	14.0%

Source: Gartner, Company data, UBS estimates

Figure 23: NAND Flash bit demand growth by application

	Q120 QoQ	Q220 QoQ	Q320 QoQ	Q420 QoQ	2020 YoY	Q121E QoQ	Q221E QoQ	Q321E QoQ	Q421E QoQ	2021E YoY	Q122E QoQ	Q222E QoQ	Q322E QoQ	Q422E QoQ	2022E YoY
Total Embedded	-11.6%	8.7%	15.6%	13.3%	27.5%	-3.7%	8.7%	13.6%	13.1%	35.7%	-2.7%	10.7%	15.2%	12.8%	38.9%
Smartphones	-24.7%	0.0%	29.2%	13.9%	13.0%	-9.7%	4.1%	22.0%	14.4%	32.9%	-10.7%	7.0%	25.7%	13.8%	34.6%
iPhones	-39.5%	-5.2%	1.7%	107.4%	18.4%	-33.1%	-24.8%	31.8%	61.2%	18.2%	-37.1%	-4.5%	33.6%	65.8%	23.7%
Samsung	-2.3%	-19.4%	57.1%	-22.6%	-7.4%	31.3%	-3.4%	30.5%	-18.4%	35.1%	22.6%	7.1%	29.6%	-14.8%	37.5%
Non- iPhone/Samsung	-23.2%	12.6%	32.0%	-3.9%	20.7%	-5.7%	23.4%	15.5%	10.3%	39.8%	-6.4%	11.3%	21.6%	7.5%	38.5%
Tablet PCs	-14.8%	49.3%	17.8%	4.8%	60.8%	-31.4%	28.3%	2.9%	18.0%	7.0%	-30.2%	23.1%	0.5%	36.1%	8.5%
SSD-Total	-4.4%	15.0%	10.9%	14.1%	39.5%	-0.7%	10.0%	10.4%	11.4%	38.2%	2.8%	12.6%	12.6%	11.4%	43.3%
SSD (notebooks)	-23.3%	65.5%	21.5%	20.1%	66.0%	-19.5%	6.6%	11.6%	14.3%	26.6%	-9.7%	10.1%	12.1%	21.3%	28.6%
SSD (servers)	3.7%	4.2%	5.7%	6.8%	28.4%	15.3%	10.5%	9.3%	10.8%	46.0%	15.0%	17.7%	17.1%	8.7%	67.3%
SSD (storage)	3.5%	-1.2%	6.9%	33.2%	21.5%	-9.2%	9.5%	9.9%	9.1%	32.4%	7.0%	6.8%	6.5%	6.3%	34.5%
SSD (others)	1.0%	-0.6%	6.4%	8.5%	34.8%	11.3%	12.9%	10.5%	10.2%	44.5%	1.4%	11.0%	9.7%	8.2%	36.3%
Total Flash cards	-14.8%	1.5%	21.5%	7.6%	13.4%	-4.1%	10.6%	11.9%	-1.3%	27.1%	0.3%	11.0%	11.6%	1.9%	23.8%
Mobile Phones - Flash cards	-12.2%	-5.1%	29.7%	9.9%	10.3%	-10.6%	1.8%	5.7%	1.2%	11.6%	0.5%	3.4%	5.7%	0.5%	10.5%
Total Bit Demand	-11.9%	8.2%	16.0%	12.9%	26.4%	-3.8%	8.8%	13.5%	12.1%	35.1%	-2.5%	10.7%	15.0%	12.1%	37.9%

Source: Gartner, Company data, UBS estimates

Figure 24: NAND Flash content assumptions (MB/unit) by application

	Q120	Q220	Q320	Q420	2020	Q121E	Q221E	Q321E	Q421E	2021E	Q122E	Q222E	Q322E	Q422E	2022E
Smartphones - Blended	98,501	97,646	103,776	108,025	102,514	118,672	124,255	138,162	132,704	128,910	148,025	159,266	182,409	174,488	166,907
% YoY	39%	41%	27%	11%	28%	20%	27%	33%	23%	26%	25%	28%	32%	31%	29%
iPhones	185,467	187,433	180,224	193,331	183,482	193,331	193,331	226,099	226,099	206,663	226,099	226,099	288,358	308,019	261,843
Samsung	118,303	102,432	108,699	110,272	109,943	120,391	118,191	143,327	138,240	130,067	154,658	152,838	183,976	173,301	166,715
Others	78,000	83,500	88,000	92,000	85,841	100,000	110,000	120,000	130,000	115,772	140,000	150,000	160,000	170,000	155,839
SSD - Notebook PCs (GB)	304	320	340	346	331	350	350	391	439	383	446	446	458	518	469
% YoY	13%	23%	22%	13%	19%	15%	10%	15%	27%	16%	27%	27%	17%	18%	23%
SSD- Servers (GB)	1,690	1,749	1,821	1,908	1,793	2,103	2,250	2,396	2,543	2,329	2,836	3,129	3,519	3,910	3,361
% YoY	5%	7%	10%	15%	9%	24%	29%	32%	33%	30%	35%	39%	47%	54%	44%
SSD- Storage (GB)	3,948	4,241	4,533	4,961	4,438	5,254	5,547	5,840	6,133	5,708	6,328	6,523	6,718	6,914	6,629
% YoY	10%	17%	22%	32%	21%	33%	31%	29%	24%	29%	20%	18%	15%	13%	16%

Source: Gartner, Company data, UBS estimates

Figure 25: Memory players capex breakdown

Capex breakdown	2017	YoY%	2018	YoY%	2019	YoY%	2020	YoY%	2021E	YoY%	2022E	YoY%
Memory Total	43,205	50.9%	55,225	27.8%	41,189	-25.4%	46,465	12.8%	51,684	11.2%	54,243	4.9%
Samsung	17,512	102.7%	18,051	3.1%	12,747	-29.4%	18,474	44.9%	22,422	21.4%	19,694	-12.2%
SK Hynix	8,698	-76.7%	14,206	63.3%	11,240	-20.9%	8,224	-26.8%	9,667	17.6%	14,467	49.7%
Micron	5,390	-11.5%	8,730	62.0%	8,533	-2.3%	9,030	5.8%	8,550	-5.3%	10,400	21.6%
Intel	2,500	66.7%	4,500	80.0%	1,775	-60.6%	2,000	12.7%	2,000	0.0%	0	NA
Kioxia (Toshiba Memory)	4,940	85.3%	3,942	-20.2%	3,150	-20.1%	3,636	15.4%	2,545	-30.0%	3,182	25.0%
Western Digital (SanDisk)	788	-49.8%	1,070	35.8%	1,080	0.9%	1,000	-7.4%	1,500	50.0%	1,750	16.7%
Nanya	956	36.3%	662	-30.7%	244	-63.2%	250	2.7%	500	100.0%	500	0.0%
Inotera												
YMTC	1,000	NM	2,000	100.0%	3,000	50.0%	3,250	8.3%	4,000	23.1%	4,000	0.0%
Fujian Jinhua IC	1,000	0.0%	2,000	100.0%	0	-100.0%	0	NM	0	NM	0	NM
CXMT (Innotron)	1,000	0.0%	1,000	0.0%	500	-50.0%	1,600	220.0%	2,000	25.0%	2,000	0.0%
DRAM total	16,364	74.1%	25,053	53.1%	17,816	-28.9%	23,427	31.5%	24,663	5.3%	27,426	11.2%
Samsung	5,840	81.9%	9,707	66.2%	5,713	-41.1%	9,195	60.9%	10,503	14.2%	9,329	-11.2%
SK Hynix	4,293	14.4%	6,841	59.3%	7,093	3.7%	5,609	-20.9%	6,207	10.7%	8,607	38.7%
Micron	3,219	24.4%	4,365	35.6%	4,267	-2.3%	6,773	58.7%	4,703	-30.6%	6,240	32.7%
Nanya	956	36.3%	662	-30.7%	244	-63.2%	250	2.7%	500	100.0%	500	0.0%
Inotera												
YMTC									750	NM	750	NM
Fujian Jinhua IC	1,000		2,000	100.0%	0	-100.0%	0	NM	0	NM	0	NM
CXMT (Innotron)	1,000		1,000	0.0%	500	-50.0%	1,600	220.0%	2,000	25.0%	2,000	0.0%
NAND total	26,840	39.5%	30,172	12.4%	23,373	-22.5%	23,039	-1.4%	27,022	17.3%	26,817	-0.8%
Samsung	11,673	115.0%	8,344	-28.5%	7,034	-15.7%	9,280	31.9%	11,919	28.4%	10,365	-13.0%
SK Hynix	4,405	124.5%	7,365	67.2%	4,147	-43.7%	2,615	-37.0%	3,460	32.3%	5,860	69.4%
Micron	2,380	-32.3%	4,365	83.4%	4,267	-2.3%	2,258	-47.1%	3,848	70.4%	4,160	8.1%
Intel	2,500	66.7%	4,500	80.0%	1,775	-60.6%	2,000	12.7%	2,000	0.0%	0	NA
Kioxia (Toshiba Memory)	4,940	85.3%	3,942	-20.2%	3,150	-20.1%	3,636	15.4%	2,545	-30.0%	3,182	25.0%
Western Digital (SanDisk)	788	-49.8%	1,070	35.8%	1,080	0.9%	1,000	-7.4%	1,500	50.0%	1,750	16.7%
YMTC	1,000	NM	2,000	100.0%	3,000	NM	3,250	8.3%	3,250	0.0%	3,250	0.0%

Source: Company data, UBS estimates

Figure 26: Memory WFE breakdown

WFE	2017	YoY%	2018	YoY%	2019	YoY%	2020	YoY%	2021E	YoY%	2022E	YoY%
Memory	26,400	55.5%	34,350	30.1%	22,250	-35.2%	29,000	30.3%	33,750	16.4%	36,150	7.1%
DRAM	9,100	49.2%	15,550	70.9%	9,750	-37.3%	13,350	36.9%	14,750	10.5%	16,450	11.5%
NAND	17,300	59.0%	18,800	8.7%	12,500	-33.5%	15,650	25.2%	19,000	21.4%	19,700	3.7%

Source: 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\$84.01	US\$90	3.6	2.6	2.3	8.4	4.6	4.1	19.5	8.3	7.4	2.21	1.80	1.49
Samsung Elec.	Buy	Won83,000	Won100000	1.7	1.5	1.5	6.0	4.9	4.8	18.1	13.3	13.2	2.07	1.84	1.70
SK Hynix	Buy	Won125,000	Won160000	2.6	2.0	2.1	4.9	3.3	4.2	11.9	6.4	8.9	1.56	1.29	1.15
Western Digital	Neutral	US\$62.12	US\$56	1.0	1.0	0.9	5.8	4.1	3.9	21.3	9.9	9.2	1.78	1.53	1.35
Average				2.2	1.8	1.7	6.3	4.2	4.3	17.7	9.5	9.7	1.91	1.61	1.42
Semicap Equipment															
ASML	Neutral	€467.10	€445	12.0	10.3	9.5	35.7	28.0	24.8	45.1	34.3	30.1	13.24	11.64	10.04
ASM Pacific Tech.	Neutral	HK\$118.60	HK\$90	2.5	2.2	2.1	10.8	9.6	9.1	20.3	18.1	17.6	3.52	3.23	2.99
Applied Materials	Neutral (CBE)	US\$106.19	US\$105	4.8	4.6	4.6	16.0	15.8	15.7	19.1	18.4	17.8	9.41	9.15	9.12
Disco	Neutral	¥33,950	¥30000	6.1	5.7	5.3	17.2	15.8	14.4	29.7	27.7	25.6	4.45	4.03	3.64
Eugene Technology	Buy	Won40,700	Won39000	2.3	1.8	1.6	8.9	7.4	6.2	13.9	12.1	11.1	2.97	2.37	1.94
Tokyo Electron	Buy	¥41,150	¥49000	3.8	3.6	3.4	13.6	12.4	11.6	21.3	19.7	19.0	5.80	5.06	4.47
KLA Corporation	Neutral	US\$302.26	US\$280	7.2	6.8	6.5	18.1	17.7	17.1	22.6	21.6	20.4	13.91	12.30	10.85
LAM Research	Buy	US\$532.78	US\$570	5.3	5.1	4.6	16.5	15.9	13.9	20.7	19.7	16.5	12.81	12.82	11.73
SCREEN Holdings	Neutral	¥8,390	¥5900	1.1	1.0	1.0	10.3	8.9	8.0	21.9	19.0	17.8	1.97	1.83	1.70
Teradyne	Sell	US\$129.09	US\$108	6.7	6.4	6.1	21.2	21.1	19.7	30.1	30.2	26.3	9.61	10.09	10.82
Wonik IPS	Buy	Won47,550	Won47000	1.3	1.2	1.1	6.5	7.2	5.7	12.2	14.5	12.3	2.75	2.35	2.01
Average				4.8	4.4	4.2	15.9	14.5	13.3	24.3	22.3	20.4	7.31	6.81	6.30

Source: Company data, UBS estimates. Priced as of 8th February 2021

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Buy	FSR is > 6% above the MRA.	51%	31%
Neutral	FSR is between -6% and 6% of the MRA.	37%	29%
Sell	FSR is > 6% below the MRA.	12%	18%
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%

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Micron Technology Inc ¹⁶	MU.O	Buy	N/A	US\$84.01	08 Feb 2021
Samsung Electronics	005930.KS	Buy	N/A	Won83,000	08 Feb 2021
SK Hynix	000660.KS	Buy	N/A	Won125,000	08 Feb 2021
Tokyo Electron	8035.T	Buy	N/A	¥41,150	08 Feb 2021
Western Digital Corp ¹⁶	WDC.O	Neutral	N/A	US\$62.12	08 Feb 2021

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

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