



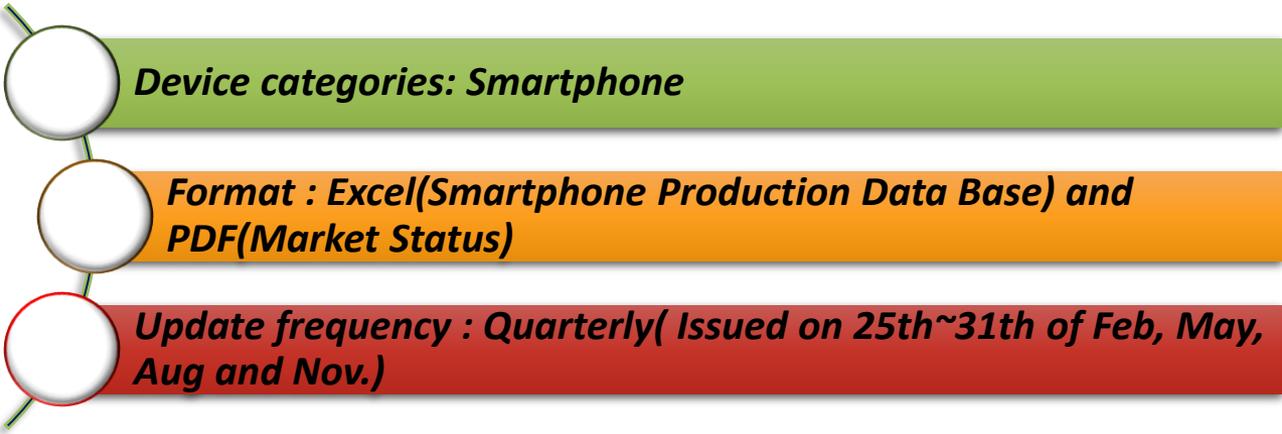
Smartphone Market Decode_3Q18

March 21, 2019

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Introduction

To provide members with a more comprehensive view of the smartphone market, TrendForce has launched a new smartphone report covering the entire smartphone industry's development. The report is a joint effort by many of the company's key research divisions, including [DRAMeXchange](#), [WitsView](#), [LEDinside](#), and [Topology](#). Its aim is to help members gain a better understanding of the ongoing trends in the smartphone industry. At the same time, it can also be used to help clients make better business decisions and risk management policies. In addition to providing key statistical data and figures from the smartphone industry, the report will offer insights on the statuses and outlooks of major smartphone components, including memory chips, panels, processors, ICs, biometric recognition systems, cameras, and facial identification technologies.



Device categories: Smartphone

Format : Excel(Smartphone Production Data Base) and PDF(Market Status)

Update frequency : Quarterly(Issued on 25th~31th of Feb, May, Aug and Nov.)

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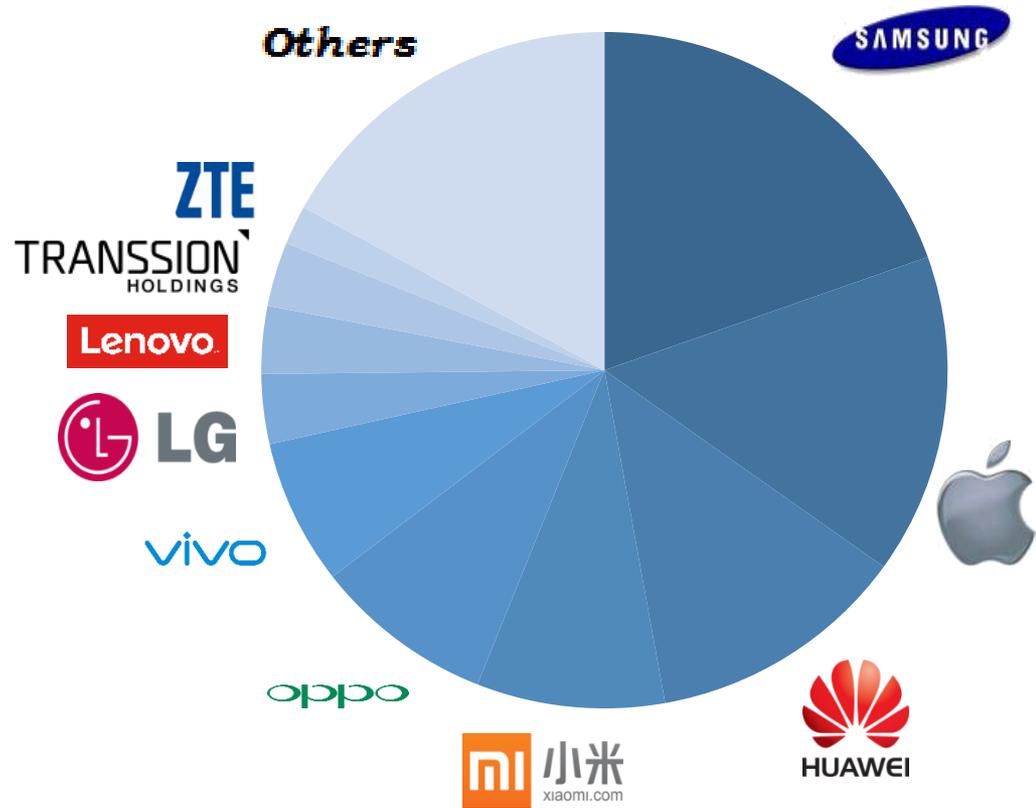
Summary

2018 Top 10 Branded Smartphone Production Volume

2018 Share % 2019

	287.7
	224.9
	180.8
	130.3
	125.2
	102.0
	49.0
	47.5
	45.2
	27.5
Others	250.0

Unit: Million **1,470.1**



Main Mobile Brands' status

Worldwide Smartphone Market	
<p>With the replacement demands on the global smartphone market slackening, branded smartphone makers have been extending their reach to the emerging markets in order to sustain their growth, by taking advantage of the growing appeal of medium- and low-tier handsets.</p>	
Samsung	<p>Due to the low differentiation in the specifications of flagship devices, Samsung's sales for this year have just been adequate, despite its leadership position on the global market. Confronted with the challenges of Chinese brands, its shares in emerging markets may drop during 2018.</p>
Apple	<p>The company is expected to continue expanding the scale of its AMOLED models in 2018, which, plus the low-price edition of its new size LCD models, will stimulate sales, resulting in slight volume growth.</p>
Huawei	<p>Thanks to the good reviews of its high-end flagship models and steady growth of demands, the company is expected to raise the visibility of its medium- and low-tier models on the overseas emerging markets in 2018, thereby sustaining its growth momentum.</p>
Xiaomi	<p>Xiaomi's success in completing its IPO in 2018 has induced the market's attention. With the gains of its deployment in emerging markets, the company has a chance to compete for the world's top four positions.</p>
OPPO/VIVO	<p>With China's domestic demands saturating, OPPO/VIVO are striving to sustain their growth via the further penetration of the second-tier smartphone market, on top of foraying into the overseas emerging markets.</p>

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WW Supply Bit Distribution

MI change of Aug. –

2018 Supply YoY: **20.8%**

2019 Supply YoY: **22.2%**

Year of 2018

YoY(%)

PC	8.2%
Server	32.3%
Mobile	18.2%
Graphic	16.6%
Consumer	22.7%

% of Total Supply

Aug. Version MI

14.0%
30.5%
41.6%
5.4%
8.6%

Year of 2019

YoY(%)

PC	
Server	
Mobile	
Graphic	
Consumer	

% of Total Supply

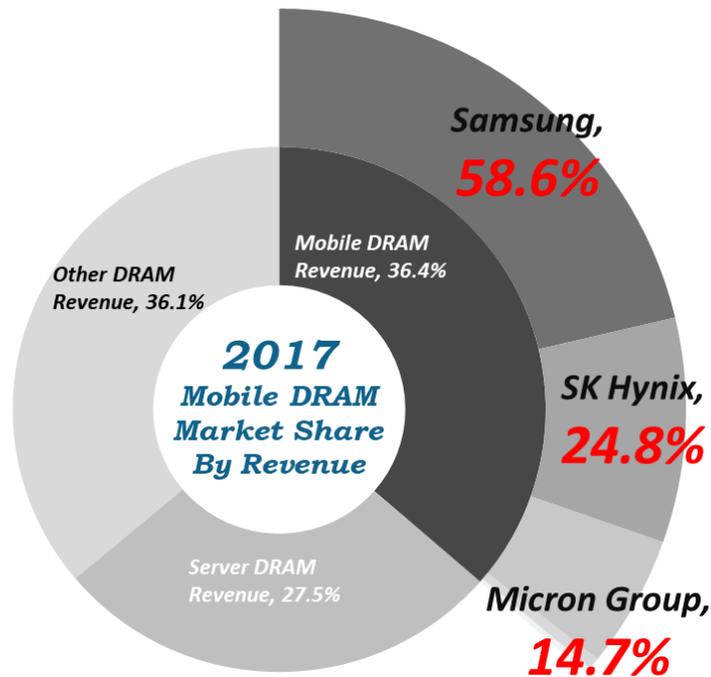
Aug. Version MI

Mobile DRAM Revenue Market Distribution

- Mobile DRAM market revenue share still stands at No. 1 from the beginning of 2015.
- Samsung is still seen as the market's leader.

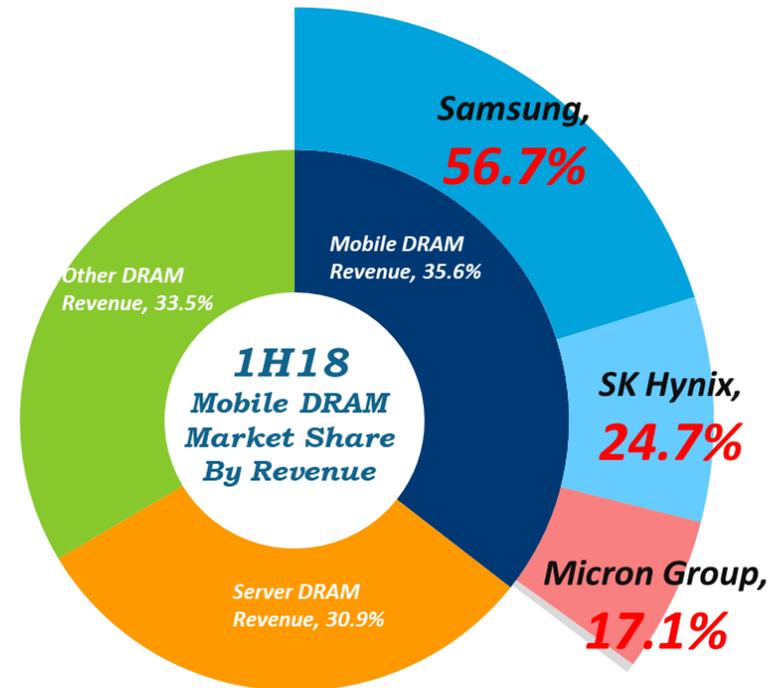
2017 Mobile DRAM Market Share

Total Mobile Revenue : **36.4%** of Total DRAM Revenue



2018 1H Mobile DRAM Market Share

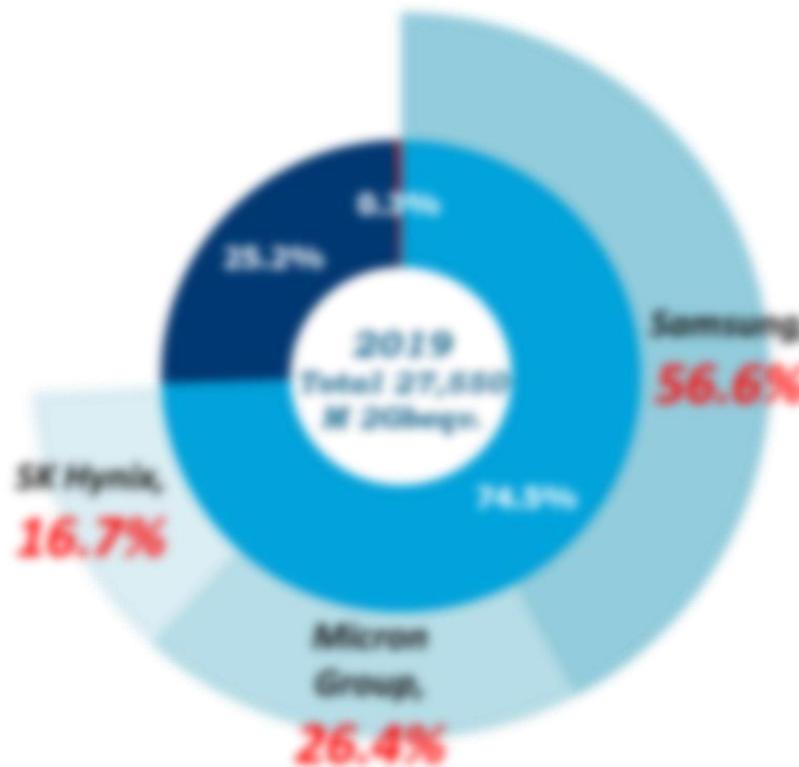
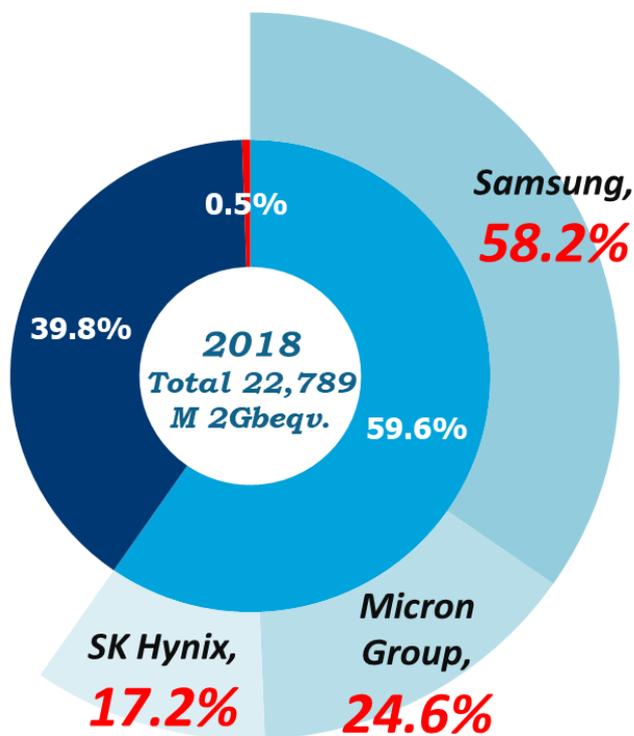
Total Mobile Revenue : **35.6%** of Total DRAM Revenue



LPDDR4 Series Will Become Mainstream from 2018

- LPDDR4 series is the next gen Mobile DRAM product with great improvements in power efficiency (1.1V&0.6V VDD2/VDDQ).
- LPDDR4 series applications will become the majority in 2018.

Product Type by Production, 2018E-2019F

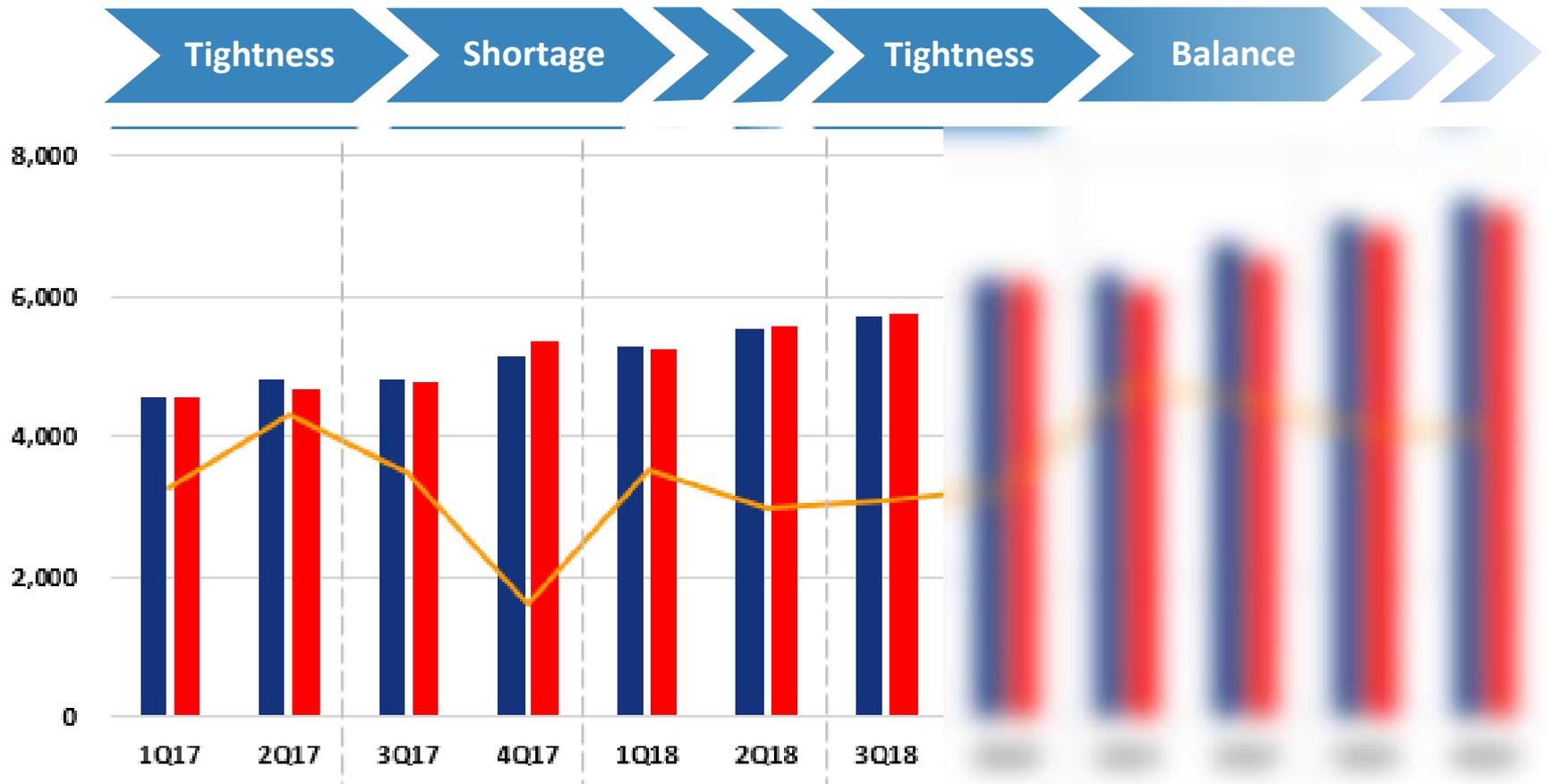


Overall Demand Outlook of Devices

Item	2018		2019	
	Shipment	YoY	Shipment	YoY
PC	264.2 M	-2.3%		
Notebook (by ODM)	164.5 M	-0.1%		
Tablet PC	150.0M	-1.3%		
Server	12.4 M	4.9%		
Smartphone (Production Volume)	1,470.1 M	0.9%		
Feature phone	524.1 M	-0.1%		

Mobile DRAM Industry Outlook

- Samsung Pyeongtaek will join the production out-put from 2H'18 and it will ease the shortage situation.
- Server demand is strong and profit is higher than other applications, it will easily cause the capacity crowding-out situation.



2018~2019 ASP Projection - Sequential

QoQ %	1Q18	2Q18	3Q18	4Q18F	2018 Estimate (YoY)	2019 Forecast (YoY)
PC DRAM	~6%	~3%	~1.5%			
Server DRAM	3~5%	~3%	~1%			
Mobile DRAM	Discrete: 2~5% eMCP: flat ~3%	Discrete: flat~3% eMCP: -2%~flat	Discrete: flat eMCP: -3%~ flat			
Graphic DRAM	~15%	~15%	-3%			
Specialty DRAM	~3%	~3%	Flat			
Total DRAM	>5%	>3%	>3%			

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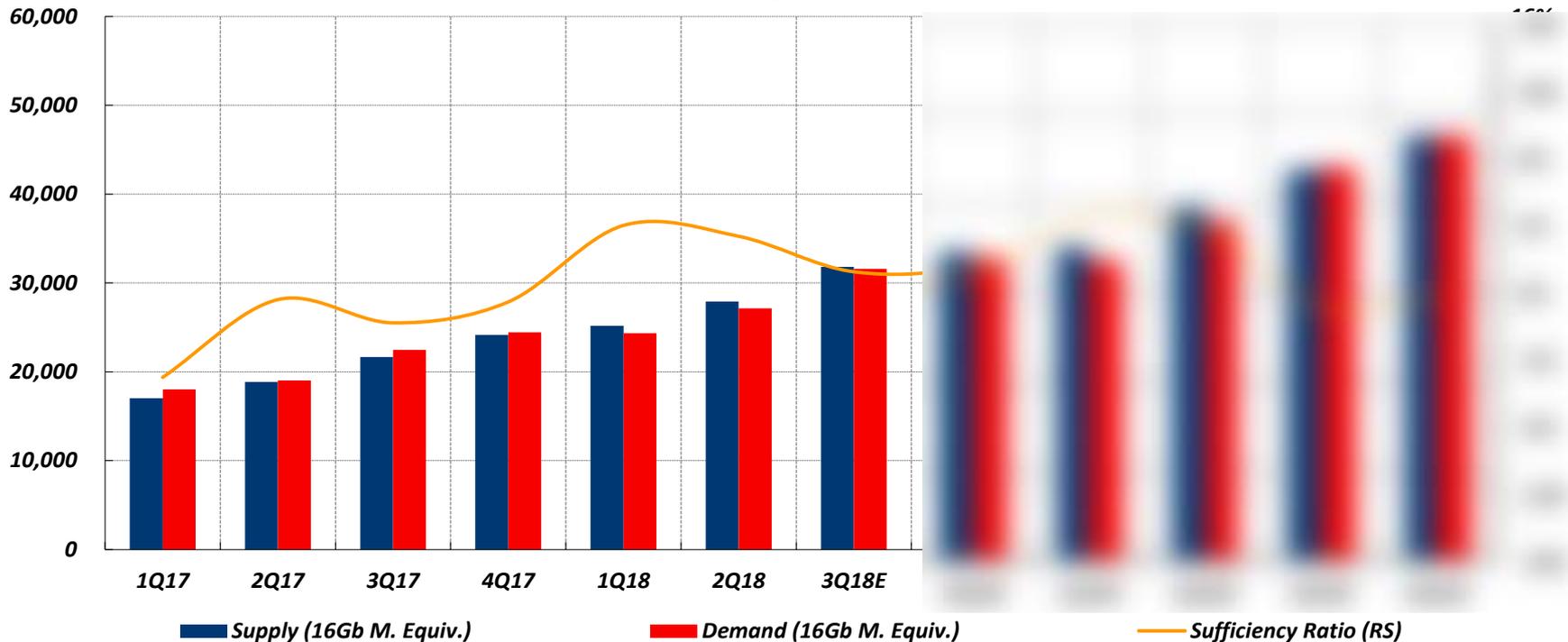
Summary

NAND Flash – 1H Oversupply, 2H Supply Tight

- Prices fell in NAND Flash market during 1H18 due to oversupply caused by seasonal downturn in demand for smartphones, NBs, tablets, and etc. However, suppliers also used this period to promote uptake of NAND Flash products and induce clients to upgrade storage specifications of devices.
- Year-end busy season, stock-up activities related to Apple's new devices, and strong server market will drive NAND Flash demand during 2H18. Meanwhile, prices of NAND Flash products will stabilize as supply tightens.

Unit: 16Gb M. Equiv.

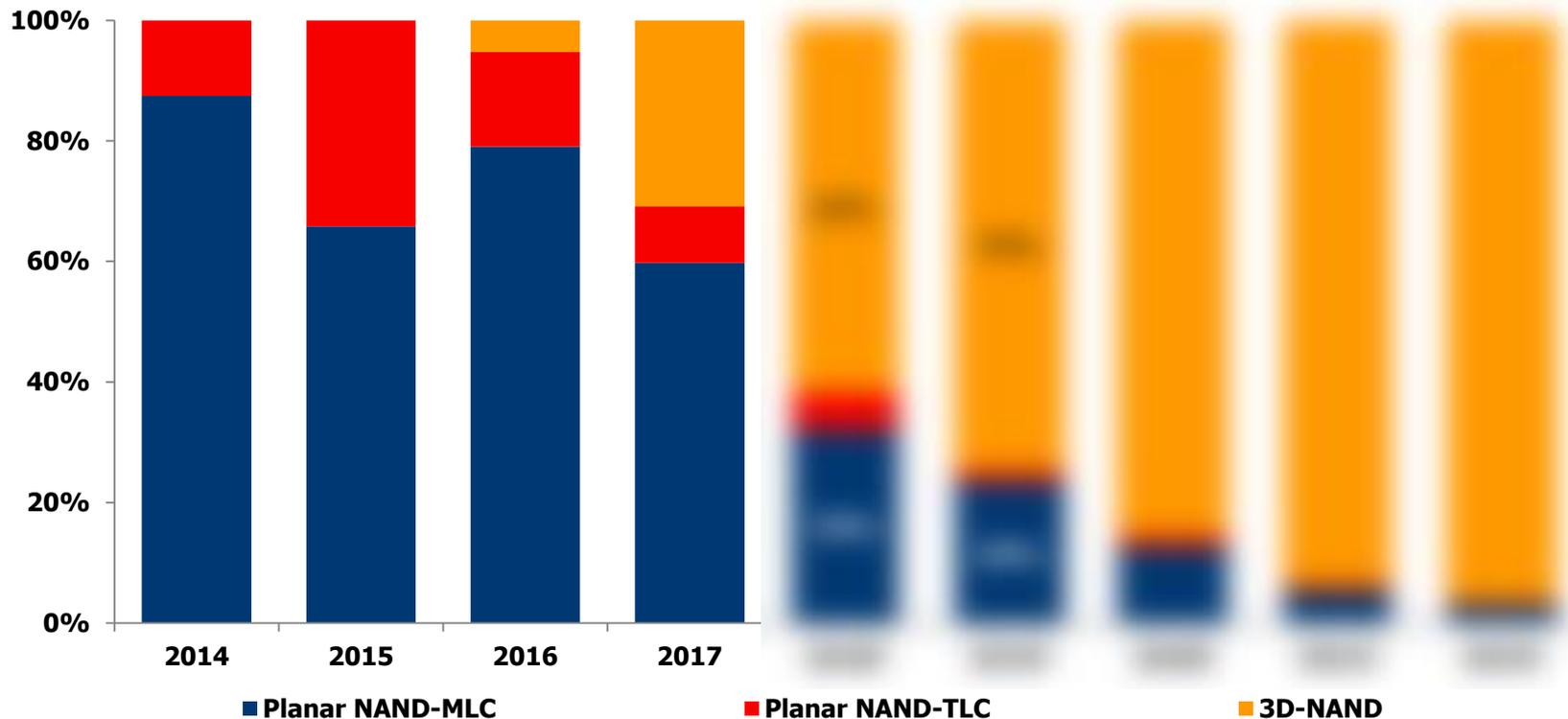
Sufficiency Ratio



Mobile NAND Flash – Architecture

- Given the capacity expansions for 64/72-layer 3D NAND flash by suppliers and the demands for higher-density products, 3D NAND eMMC/UFS will become the market mainstream in 2018, relegating the 2D architecture to niche markets.

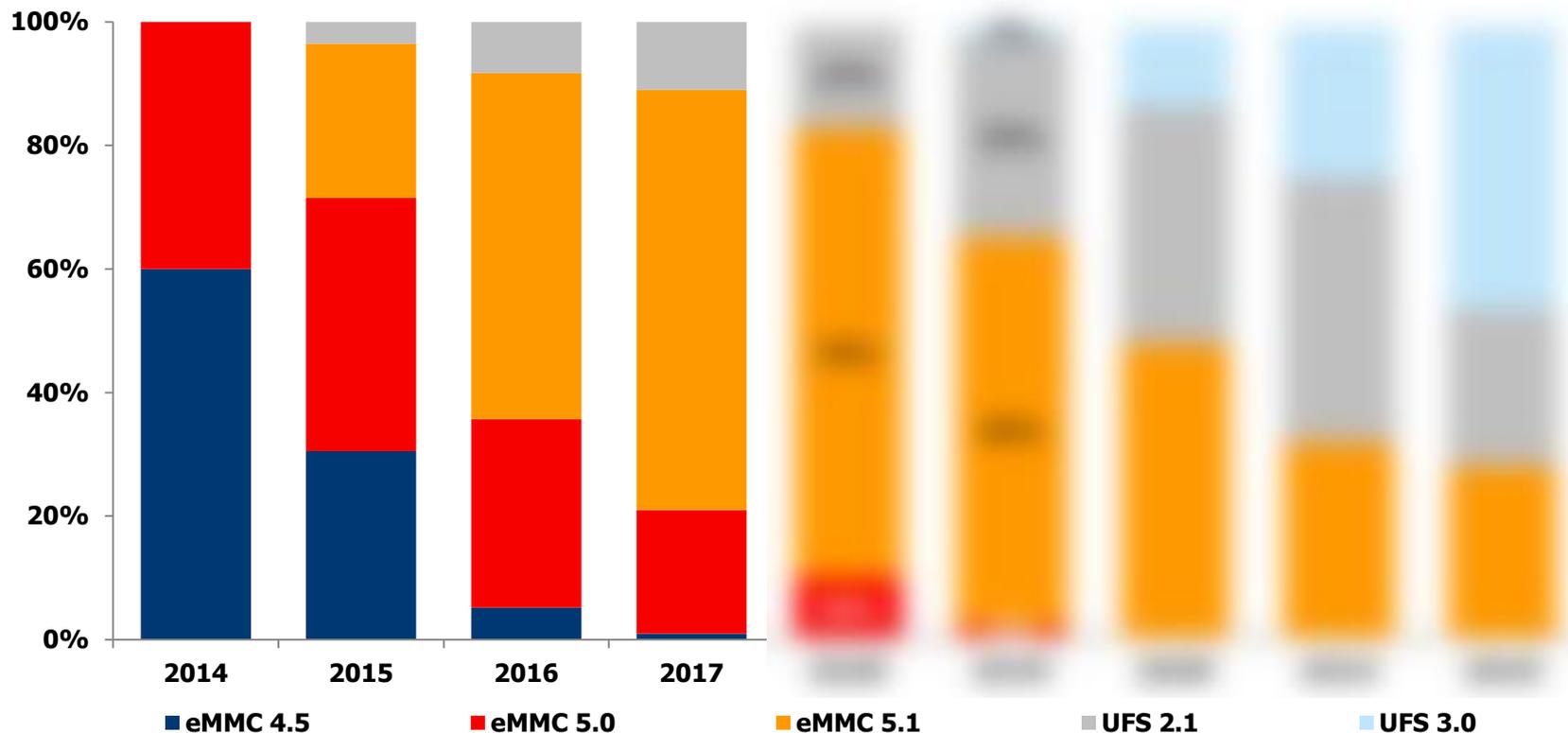
Architecture



Mobile NAND Flash – Interface

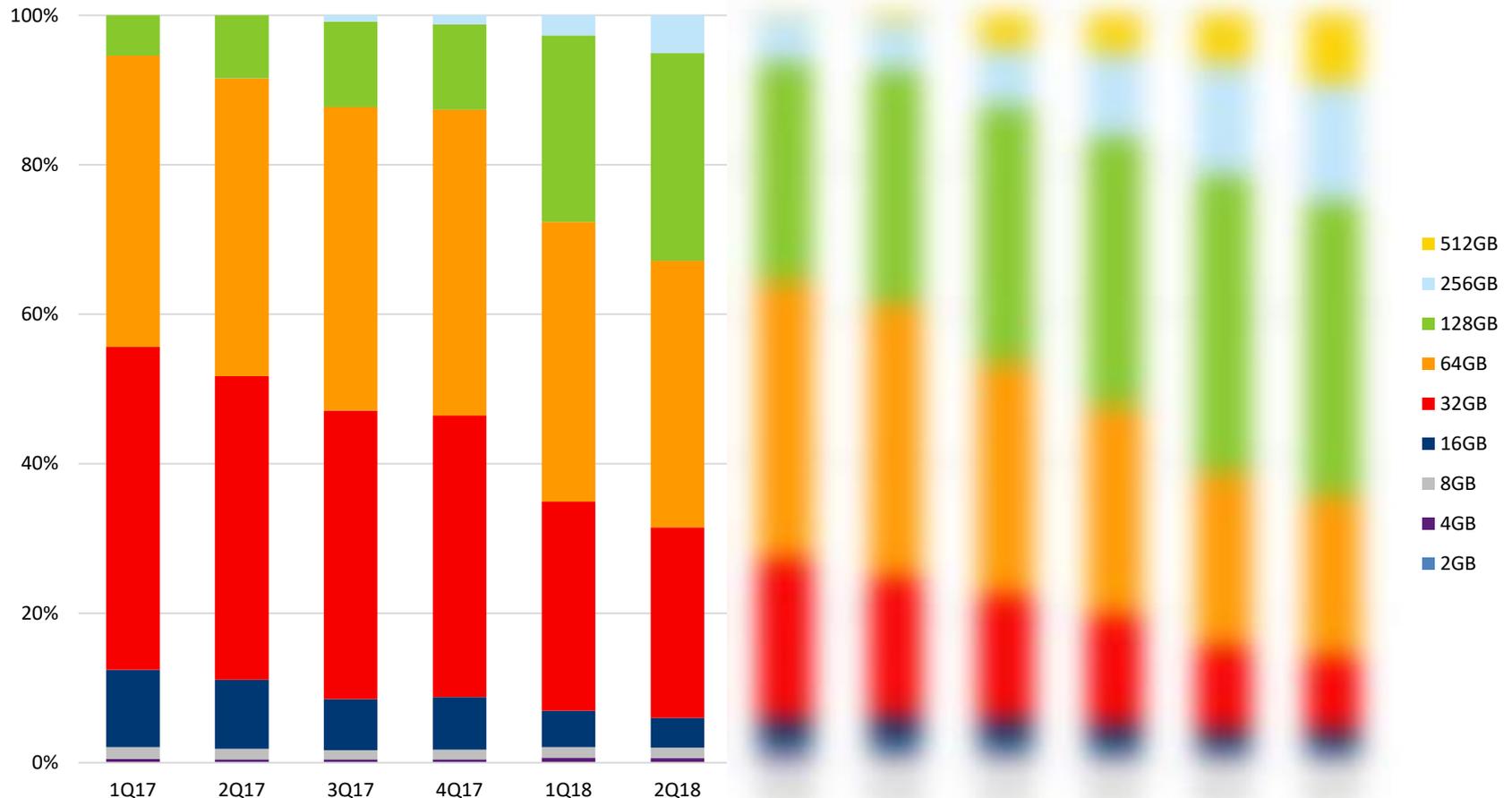
- With the adoption of UFS in high-tier flagship models having become quite common this year and the advent of the 5G era expected to boost demand for transmission speed, mid-to-high tier models will begin to switch to uMCP, from eMCP now; the UFS 3.0 standard will employ mainly 9x-layer NAND, which will gradually become mainstream.

Interface



eMMC/UFS – The Average Density Keeps Growing

- Demand that had been pent up during 2017 was finally released by decline in prices of eMMC/UFS products in 1H18. Storage of a few flagship smartphones now reach 512GB, while storage of mid-to-high-range models is now rapidly transitioning from 64/128GB to 128/256GB. Storage of mid-range models will also advance from 32GB to 64GB.



2018~2019 ASP Projection

QoQ %	1Q18	2Q18	3Q18	4Q18	2018 Forecast (YoY)	2019 Forecast (YoY)
eMMC UFS	Up 0~3% Down 0~5%	Down 0~5% Down 5~15%	Down 4~10% Down 6~11%			
Enterprise SSD	Down 2~6%	Down 8~14%	Down 10~17%			
Client SSD	Down 3~5%	Down 4~11%	Down 5~13%			
2D NAND in Module House (SLC & MLC)	Flat	Flat	Down 3~5%			
3D NAND in Module House	Down 15~20%	Down 10~20%	Down 10~20%			
Total NAND Flash	Down 5~10%	Down 15~20%	Down 8~13%			

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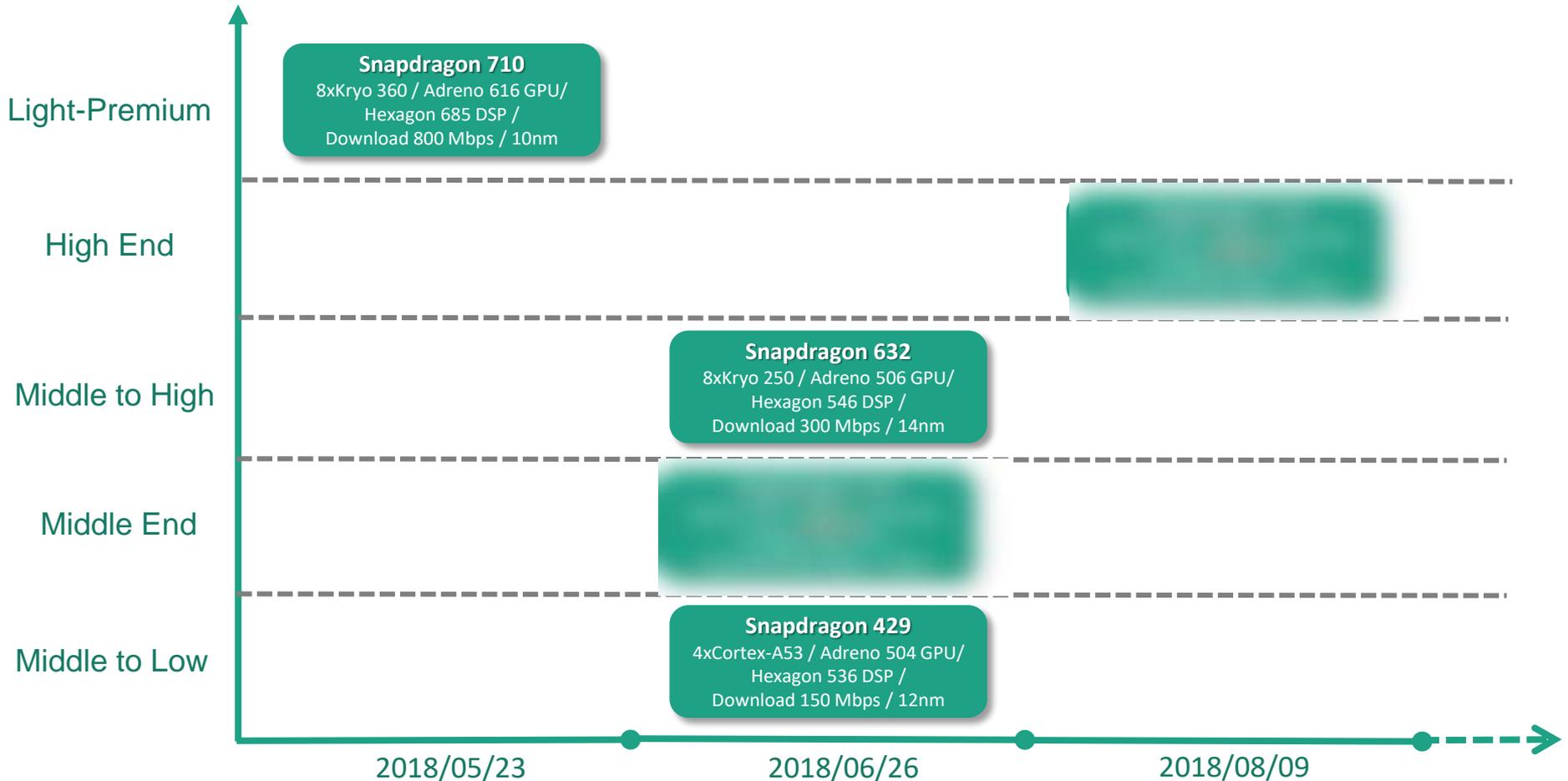
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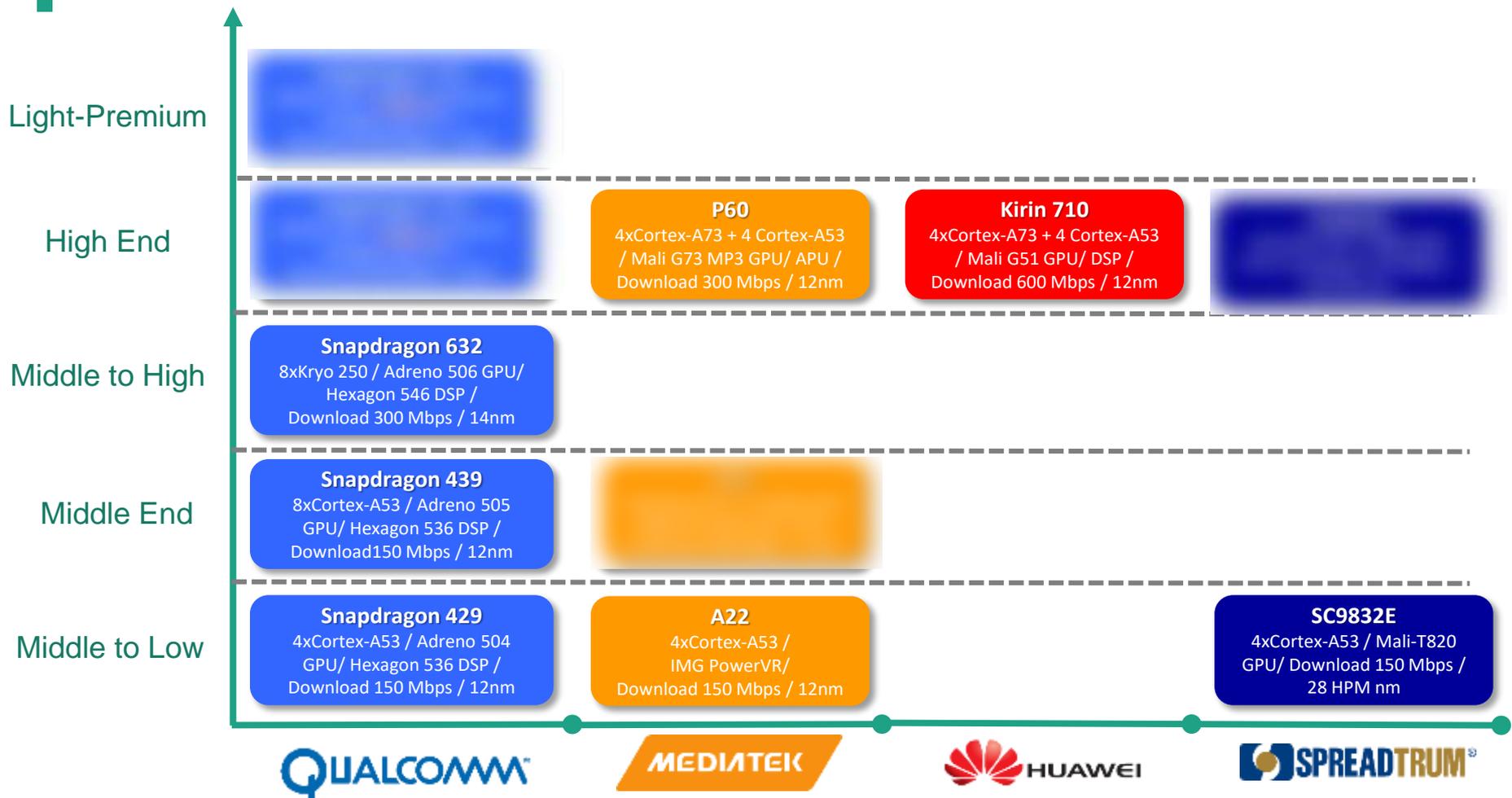
Summary

2018 H2 Qualcomm AP Strategy



- In a continuation of its 2017 strategy, Qualcomm has expanded its product lines to include light flagship models and medium- and low-tier products.
- As its 10nm technology is gradually maturing, the 10nm process has been extended to the high end products. Qualcomm's low and medium end products are still based on the 12 nm/14 nm processes.
- Qualcomm's flagship processor Snapdragon 855 will schedule for a release during Oct-Nov in 2018

2018 H2 Positioning of New APs of Various Firms



- In a continuation of its 2017 strategy, Qualcomm will continue to maintain a complete product line in 2018/ MediaTek will still be conservative towards the commercialization of advanced LTE modem technology.
- 12 nm has emerged as a mainstream technology for major processor firms. At TSMC, the scale of the technology has been expanding gradually.
- Although UNISOC is likely to employ the 12 nm process for SC9863, the employment of A55 underscores its technological ambition. The adoption of the 28 nm process for its mid to low-tier products shows its technological insufficiency in this sector.

18Q4-19Q1 Topic : New iPhone LTE Modem

New iPhone

Intel LTE Modem

XMM 7560

1.0 Gbps

Sales Time

Premium

**Android
Phone**

Qualcomm

Premium AP

Snapdragon 855

2.0 Gbps

Sales Time

Qualcomm 5G Module in 18H2

RF Module

SPEC

Bands

mmWave
(QTM052)

26.5-29.5 GHz(n257),
27.5-28.35 GHz (n261)
37-40 GHz (n260)

Sub-6 GHz
(QPM56xx)

- QPM5650 and QPM5651 feature integrated 5G NR PA/LNA/Switch and filtering subsystem
- QDM5650 and QDM5652 feature integrated 5G NR LNA/switch and filtering subsystem for diversity and MIMO support

Intel and MTK for 5G Solution in 18H2



Intel

- During the 18Q2,

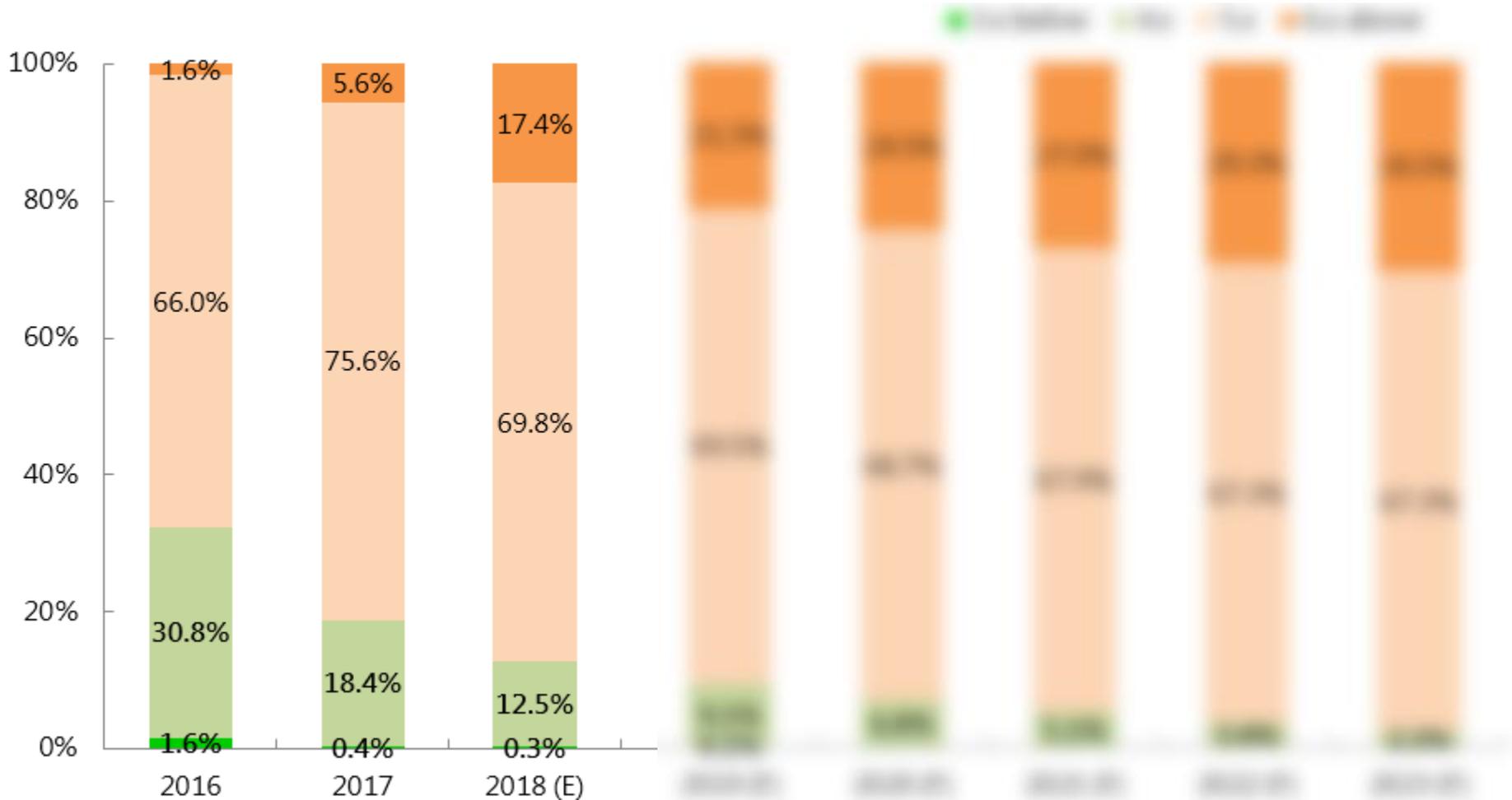
MTK

- MTK unveiled a 5G modem during.....

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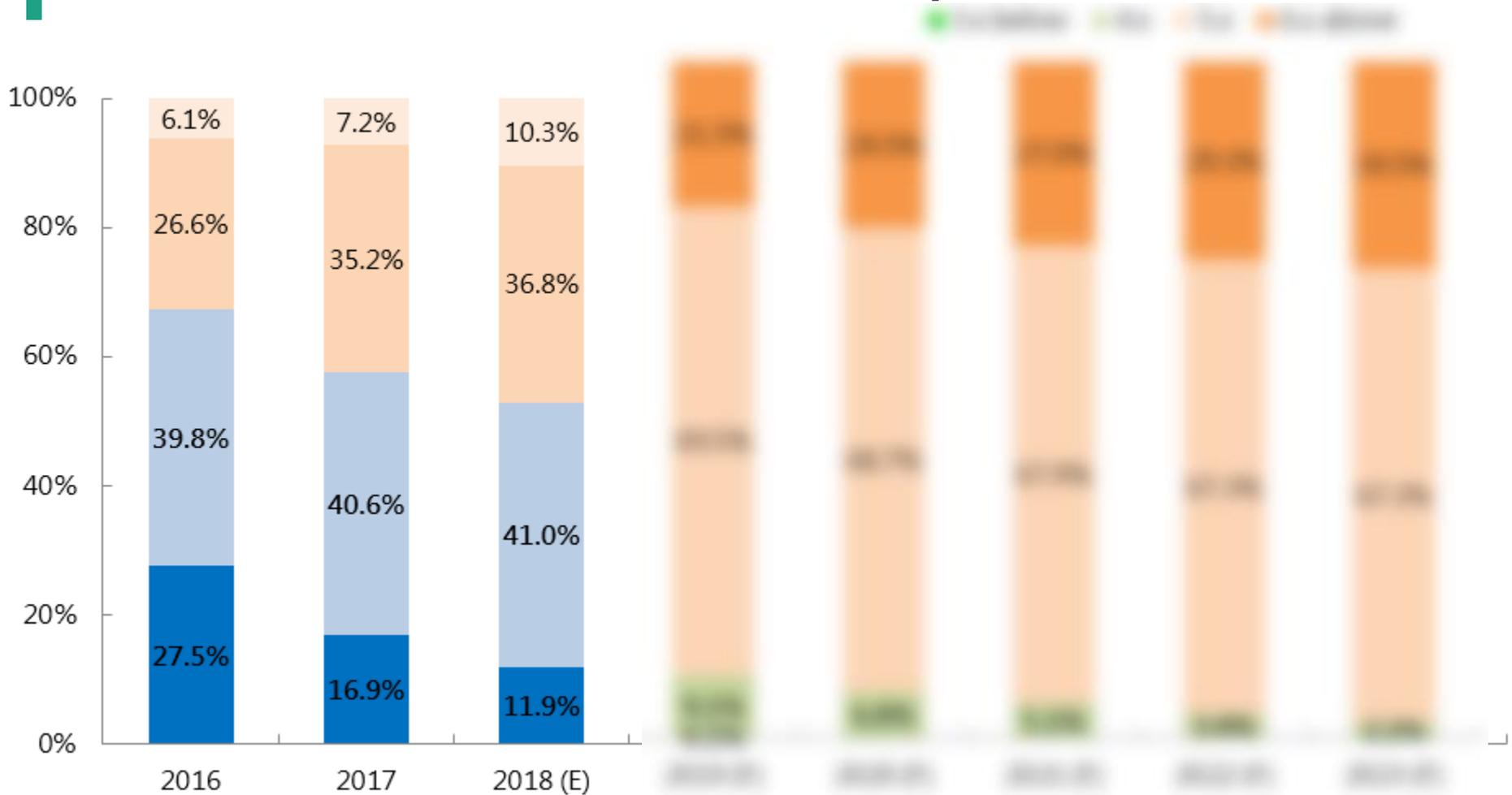
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2016~2023 Size Trend of Smartphone



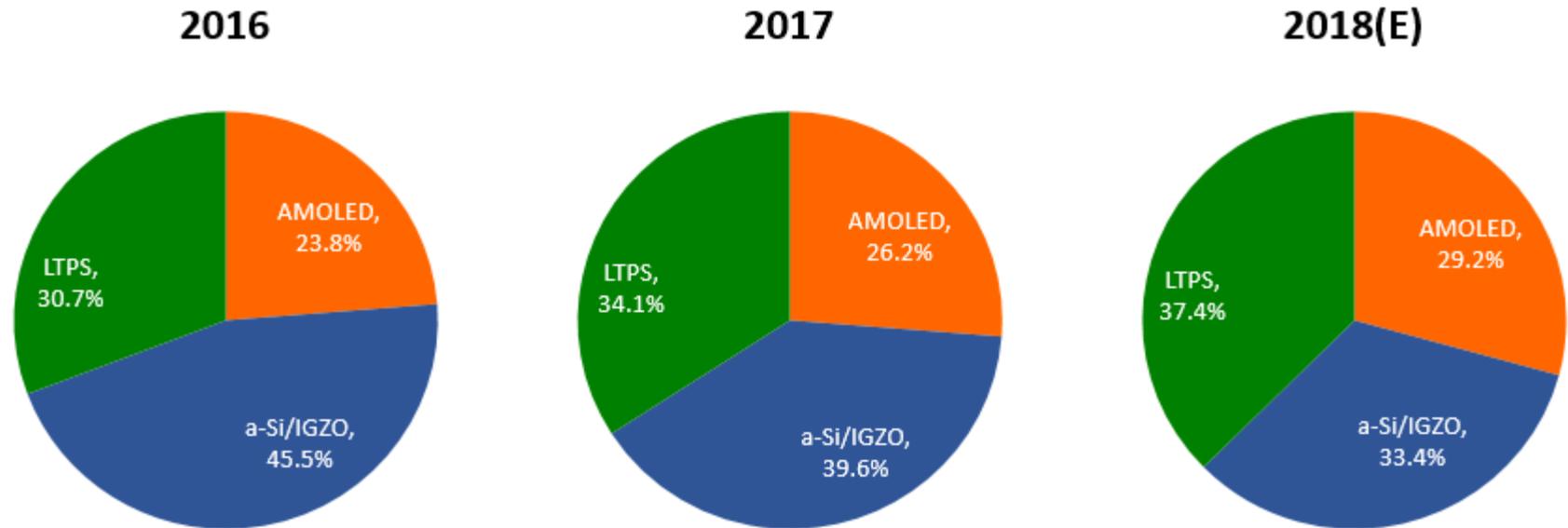
- Because of the 18:9 spec. trend, the portion of 5.x" segment shrank to below 70% in 2018, and will slightly shrink year by year.
- For the segment of 6" and above, because of the 18:9 spec. trend, its growth momentum is significant. In 2018, this segment's portion will surpass 15% and rise year by year.

2016~2023 Resolution Trend of Smartphone



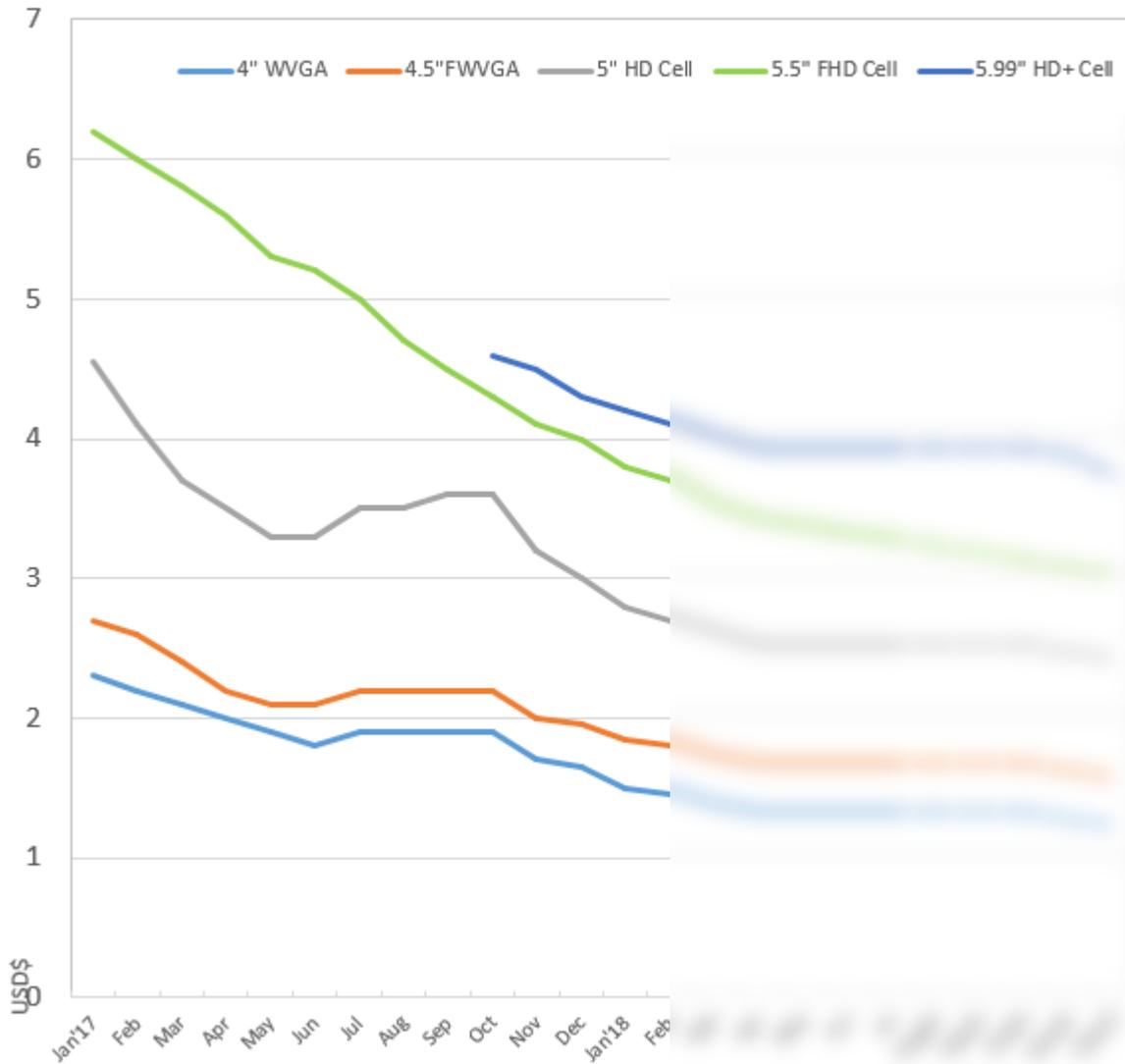
- In 2018, HD segment's portion slightly increased to 41% because mid- and low-end models' demand was decent. For FHD segment, the LTPS panel is in a severe price war, so customers' willingness to adopt FHD is rising. The FHD segment's portion continued expanding to 36.8%.
- For the segment of WQHD and above, its total portion is likely to surpass 10% because of high-end AMOLED models' demand.

Display SPEC Trend of Smartphone Market



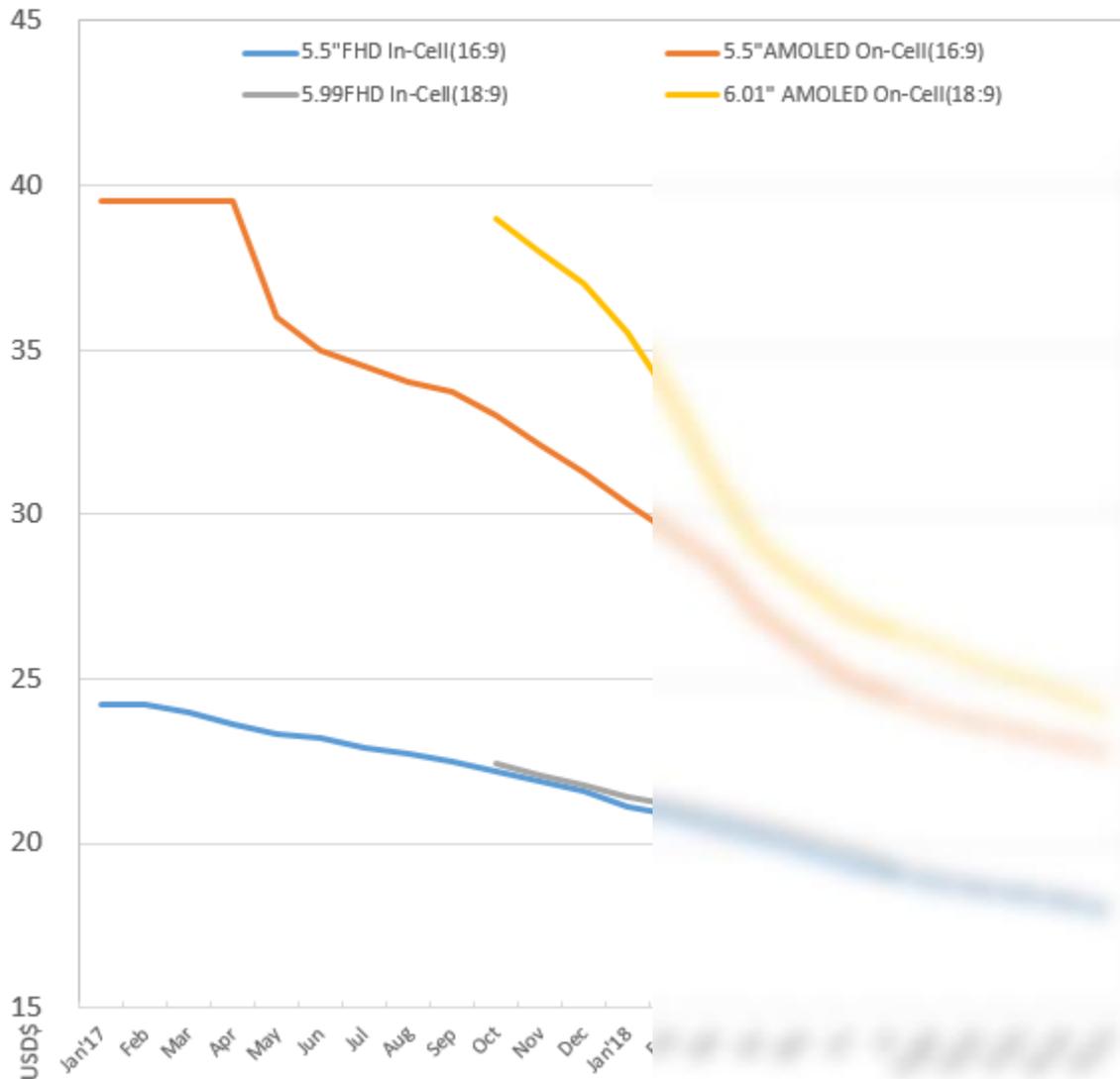
- SEC's smartphone sales are at risk of declining. In contrast, Apple's AMOLED panel portion in 2018 might be higher than that of 2017. Thus, total AMOLED model's portion is predicted to slightly increase to 29.2% in 2018. However, this figure is lower than the prediction from early this year.
- In 2018, LTPS product's portion is predicted to rise to 37.4% for 2 reasons. 1. The over-supply capacity of LTPS made the price war very severe. 2. The trend of 18:9 model continued stabilizing LTPS panel demand.
- The a-Si mid- and low-end models' portion is projected to remain at 33.4% in 2018 for the reasons below. First, there is a major cost advantage for using a-Si, even though its spec is less superior than that of LTPS and AMOLED. Second, brand customers have been increasing their focus on the mid- and low-end models in 2018, with the emerging markets as their target. As a result, there is still expected to be a certain level of demand for a-Si models.

a-Si & LTPS Cell Panel Price Trend



- In May and June 2018, the market's price reduction began to ease. From 3Q18, the prices will stop falling. However, it will be hard for the prices to rebound, as the white box and tier-two brands' negotiation power is considerably worse than the past. In contrast, smartphone brand customers have increased their focus on the low to mid-end market in 2018, so the panel makers' elbow room of raising prices for brand customers has either shrunk or disappeared completely.
- The demand of stocking-up is predicted to finish in November and December, which will lead to a potential decrease in price.

LTPS & AMOLED Panel Module Price Trend

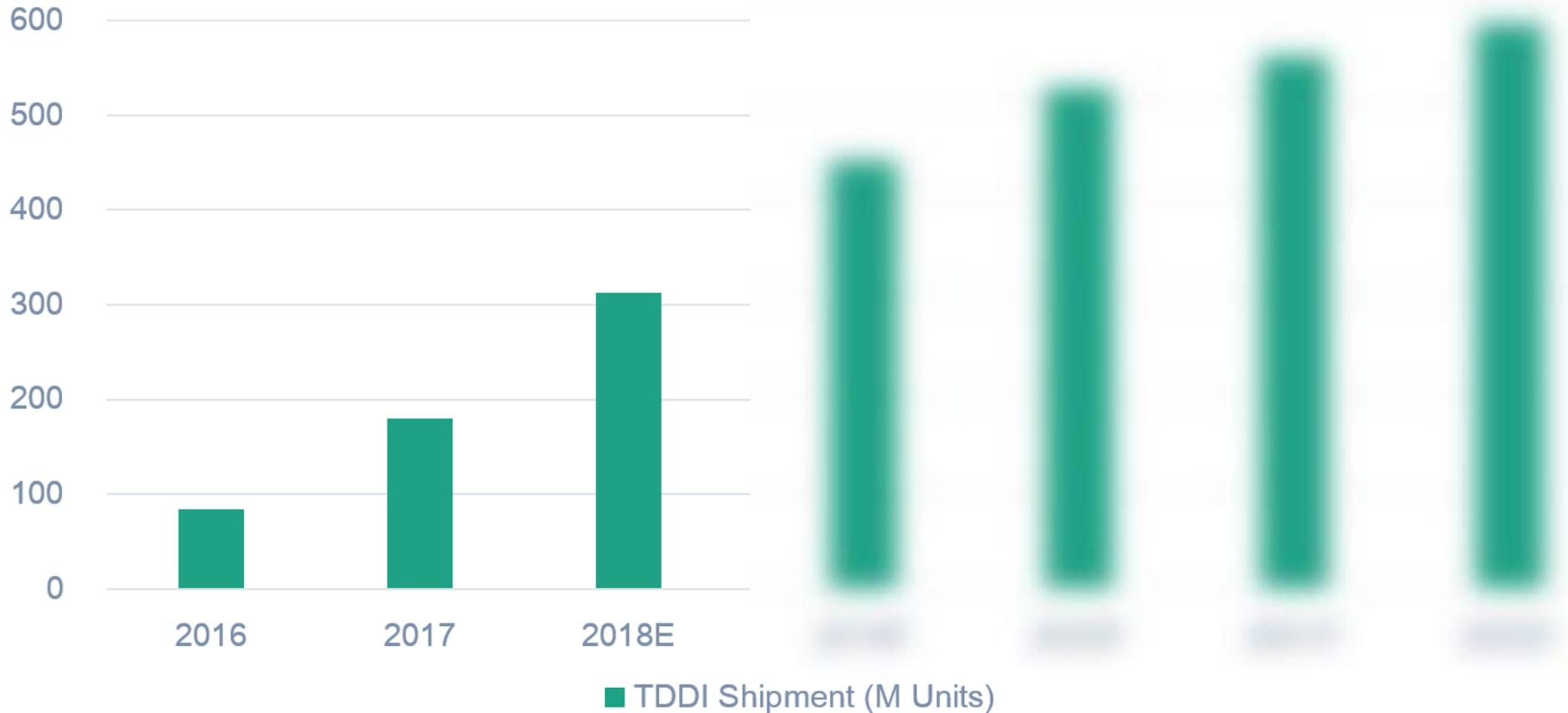


- The panel price of LTPS is unlikely to stop falling for the reasons below. On the one hand, there are continuous new models' demand from customers. On the other hand, LTPS supplies are excessive, so the price competition among panel makers has been severe. Thus, panel price has kept on falling.
- 16:9 panels are steadily replaced by 18:9 panels.
- The price of AMOLED panel is gradually approaching that of LTPS. SDC is predicted to maintain a price gap between LTPS and AMOLED panels, in order to keep AMOLED's higher-end product positioning and maintain AMOLED's price competitiveness.

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Touch/Display Integrated SoC Market Share



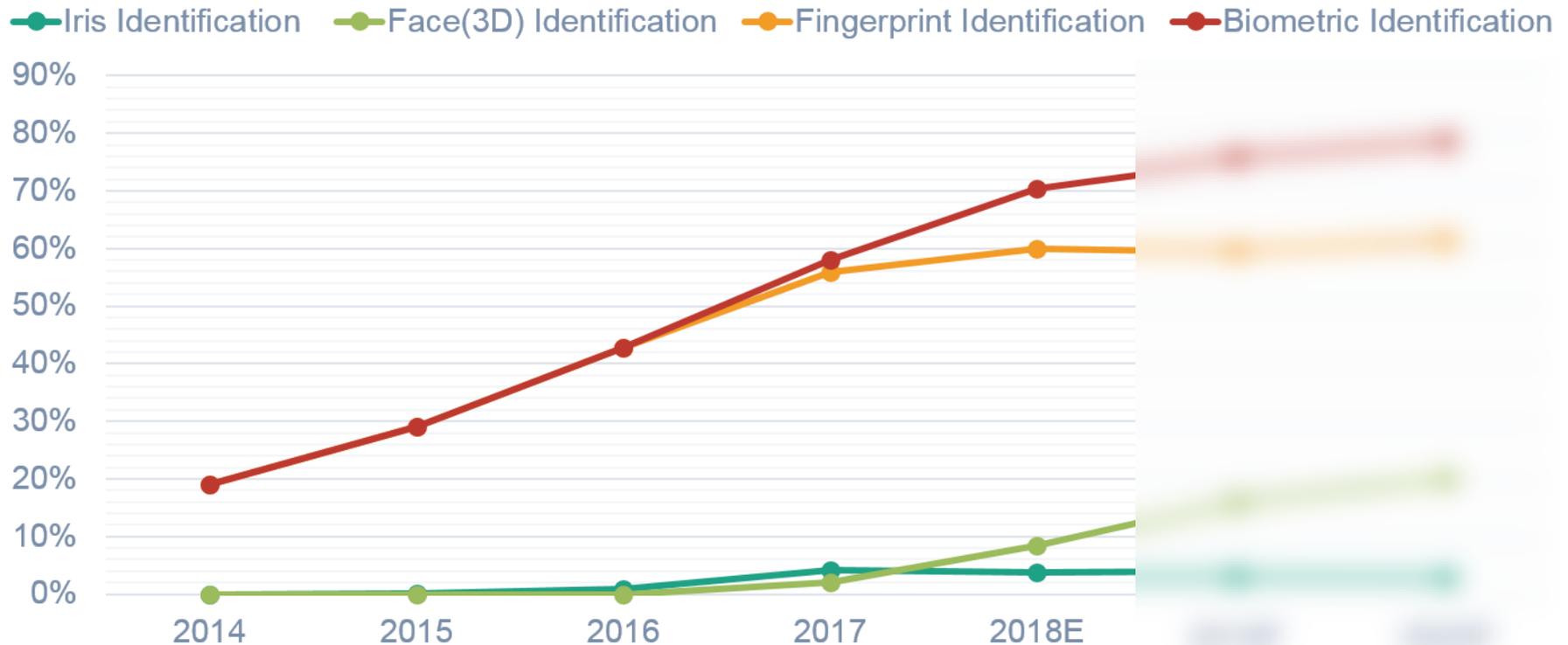
- In 2018, the capacity of TDDI IC has been tight, but it might be eased as new capacities come in at the end of 2018. TDDI technology has been used on the existing 80 nm node manufacturing process, but it will also be steadily used on the 55 nm node manufacturing process.
- Because the capacity of TDDI isn't sufficient and the cost of manufacturing is rising, the average price of all chip makers gradually increased in 2Q18. After the total balance of supply and demand is achieved, average price might drop.

COF Trend of LCD Smart Phone



- COG's lower border's narrow width can approach that of COF for two reasons. 1. FHD LTPS's TDDI IC makers began to work on interlace technology. 2. The 55nm manufacturing process can further shrink the size of chips.
- The quote price of COF is higher than that of COG. In the long term, COF fits better in AMOLED panels. LCD panel with COF will remain popular in 2018 and this combination's portion will peak in 2019. Then, the portion of LCD panel with COF will drop.

2014~2019 Biometric Identification Penetration



- From 2018~2020, the 3D facial recognition technology's penetration rate will rapidly rise for 2 reasons. 1. Apple will massively adopt Face ID on iPhones in 2018. 2. The Android camp will also begin to promote facial recognition technology.
- In 2019, the penetration rate of fingerprint recognition technology will decline for the first time because the iPhone will totally give up Touch ID. The penetration rate will only start to rebound after the technology is adopted by entry-level Android phones in 2020.
- The market share of Samsung Electronics' flagship models was eroded by Chinese brands. Meanwhile, iris recognition technology's penetration rate of smartphone is predicted to slightly drop.

Biometrics Distribution by Revenue

2016

2017

2018 E

Iris
1.63%

Fingerprint
98.37%

Iris
6.54%

3D Face
15.47%

Fingerprint
77.99%

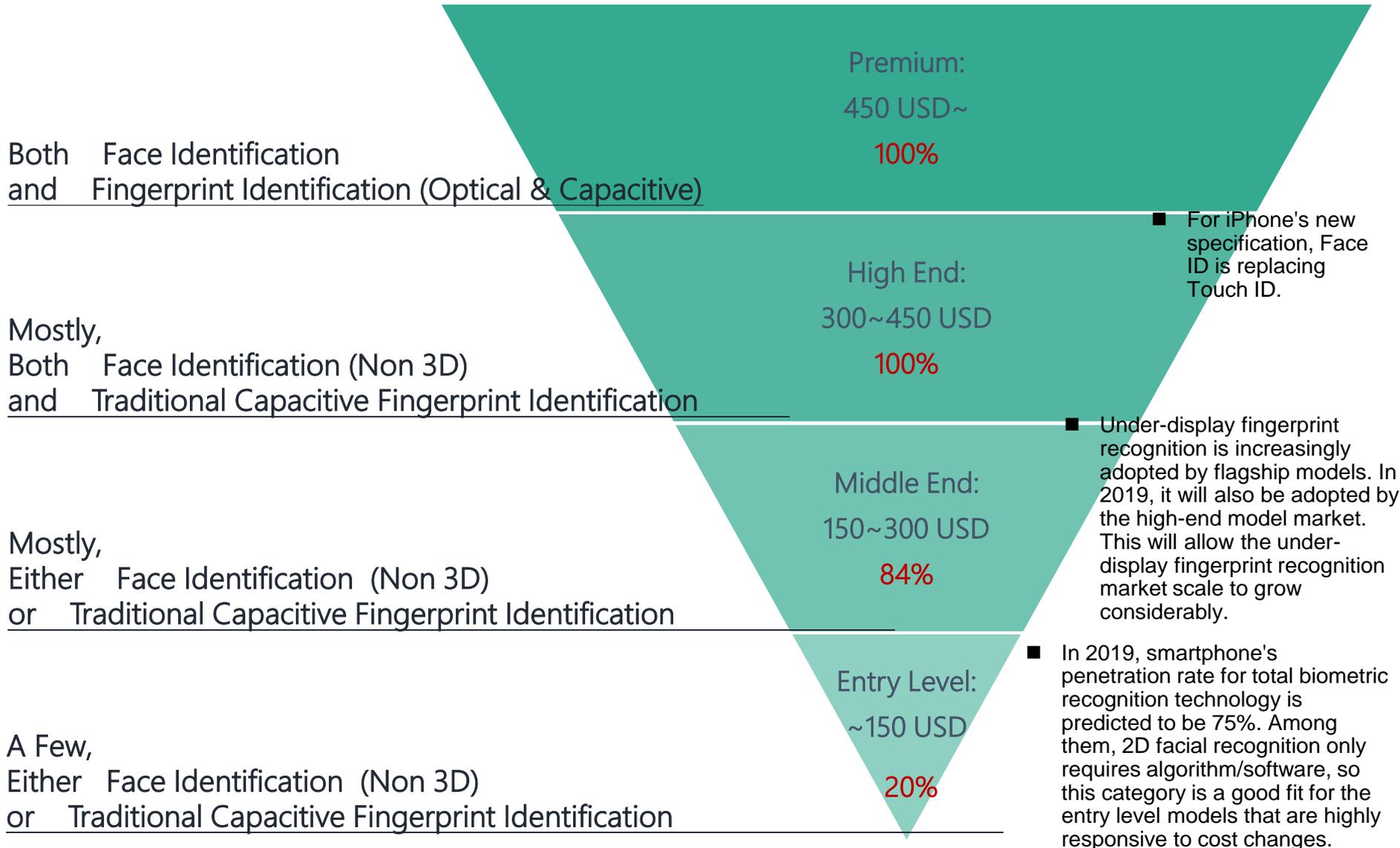
Iris
4.96%

3D Face
46.55%

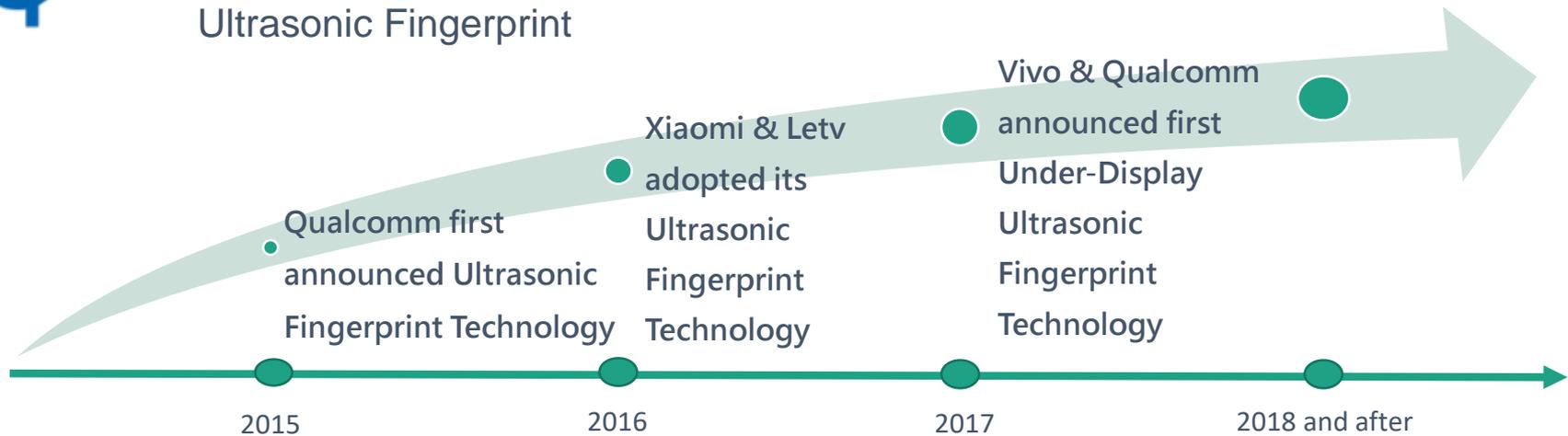
Fingerprint
48.49%

- The total smartphone biometrics recognition market value is predicted to hit US \$4.5 billion in 2018 for the 3 reasons below. 1. The price drop scale of traditional capacitive fingerprint sensing model has been declining. 2. Optical fingerprint sensing technology is approaching the mass production phase and is gaining wide attention from the market. 3. Branded manufacturers have started to enter mass production of 3D sensing module for facial recognition.
- From 2019, the Android camp's under-display fingerprint recognition module and 3D sensing module will gain more market share. The total biometrics recognition's market value is predicted to grow by double digits continuously.

2018 Biometric Trend of Smartphone Market



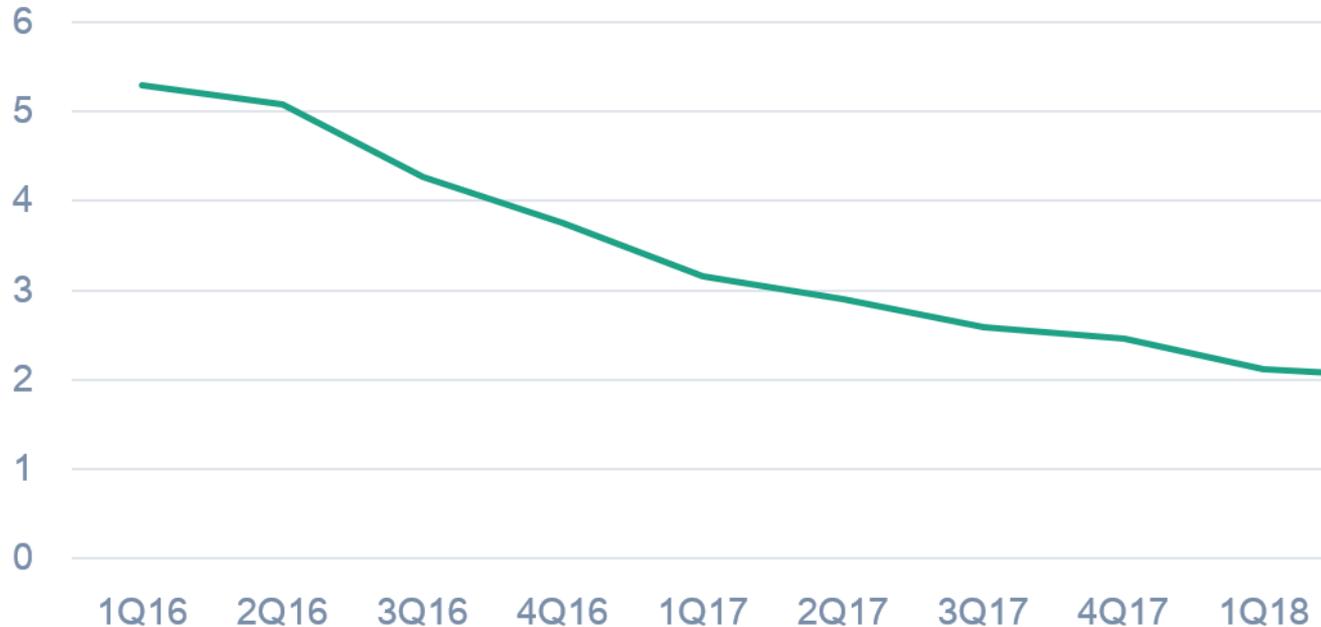
Smartphone Under-Display Fingerprints Identification



- Qualcomm is undoubtedly the representative company of ultrasonic fingerprint recognition solution. Currently its solution is only limited to flexible OLED (0.7mm panel and cover plate). Qualcomm's major collaboration module houses are GIS and O-film.
- Under-display ultrasonic fingerprint recognition is.....

Fingerprints Module Price Trend (Android)

Unit: US Dollars

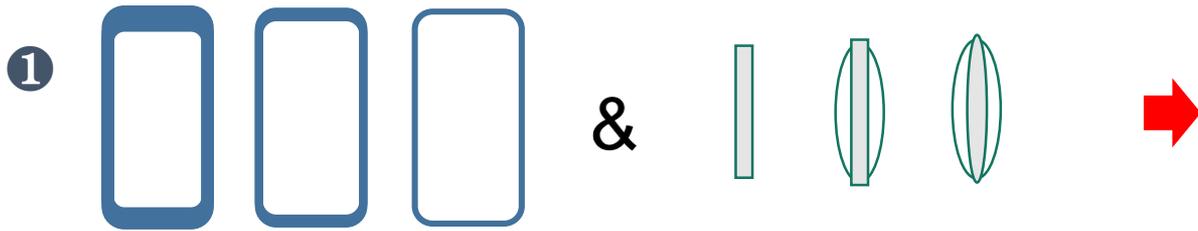


- The traditional capacitive fingerprint recognition module price has smaller elbow room to drop for 3 reasons. 1. Its price has dropped for many years consecutively. 2. The 8" wafer supply shortage has caused wafer price to rise. 3. The module's gross profit is too thin.
- Optical fingerprint recognition's product price is higher than other categories' product price, and its capacity of mass production is expanding. In 2018, its market scale is predicted to reach 30 million units. This factor will slightly reduce the average fingerprint recognition products' price drop scale.
- In 2018, the average price of fingerprint recognition module fluctuated at around US \$2. As under-display fingerprint recognition (optical and ultrasonic categories) gradually increases production quantity in 2019, the average price is likely to slightly rise.

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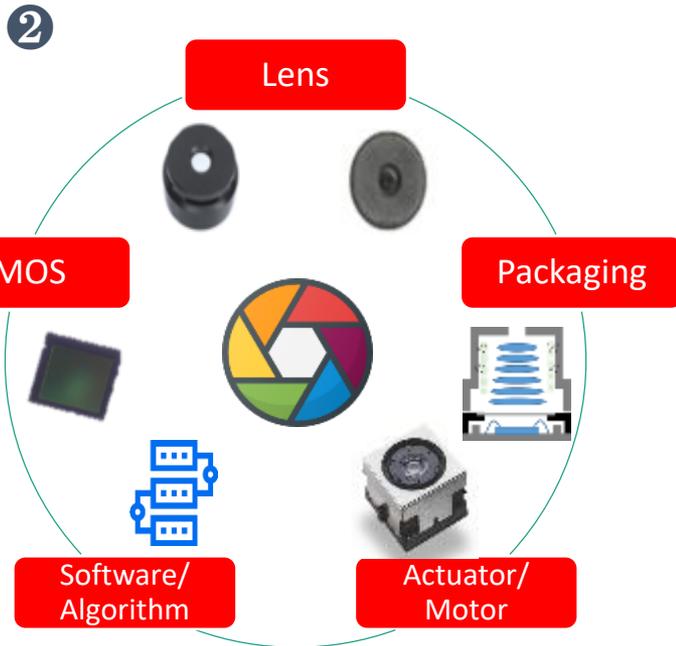
Cameras Remain the Engine of Growth for SPs



Screen-to-body ratio is approaching 100%

Migration from metal to glass has pretty much been completed in high-end devices

With the screen-to-body ratio reaching higher levels than ever and glass becoming the new mainstream casing material for high-end devices, the room for innovations is getting very limited.



Still significant room for innovations in regards to cameras:

- **Lens:** G+P and 7P will become the focus in 2019
- **CMOS:** 16MP and above may become the mainstream going forward
- **Algorithm:** greater demand particularly in image fusions
- **Packaging:** smaller form-factor, triple cam and 7P will make it more challenging.
- **Actuator:** dual and possible triple OIS



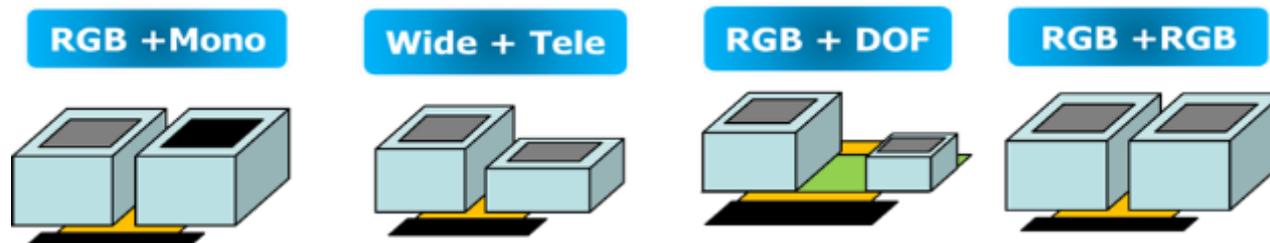
Main factors why cameras will.....

Dual-cam Becomes Standard Feature in High-End Devices

Since iPhone 7 Plus's debut in 2016, dual-cam has become a popular feature for SPs especially in high-end devices. iPhone 7 Plus along with its later generations all adopt the wide+telephoto configuration, featuring optical zoom and great Bokeh effect. Due to iPhone's popularity, many other SP brands have followed-suit and adopted the same solution. But there are actually more dual-cam configurations out there on the market, with each of its own pros and cons.



Four Major Types of Dual-Cam Solutions



RGB+Mono

- Great for low-light conditions
- Huawei is by far the largest adopter
- Usually adopted by high-end devices

High-end

Wide+Tele

- Features optical zoom and great bokeh effects
- Usually adopted by high-end devices

Middle-end

RGB+DOF

- Two RGB cameras with very different resolutions
- Mostly seen on low-end devices

Low-end

RGB+RGB

- Two RGB cameras next to each other
- Resolutions are usually the same but can be different at times
- Usually seen on low-end devices

Type of Dual Solutions in Dif. Price Segments: By Brand

- This chart shows how each brand adopts dual-cam solutions differently based on price segments.
- Each brand has a very mixed selections of solutions based on the type of products, but generally speaking they all follow the rules described earlier, with RGB+mono and wide+tele solutions predominantly seen on high-end devices and the other two on mid or low-end devices.

Price Range						
\$500 & up	Blue	Blue	Blue	Blue	Blue	Blue
\$300 & \$500	Blue	Red	Blue	Blue	Blue	Blue
\$150 & \$300	Blue	Red	Blue	Blue	Blue	Blue
\$150 & below	Red	Red	Red	Red	Red	Red

- **Samsung:** So far not very active in promoting dual-cam and its strategy isn't very clear, either.
- **Apple:** Major adopter of the wide-tele solution; very active in incorporating dual-cam to its product lines.
- **Huawei:** By far the most active advocate of dual-cam and has all types of solutions in its product lines.
- **O/V:** Both of their dual-cam strategies are still vague; OPPO has a greater variety of solutions than Vivo.
- **Xiaomi:** Second largest advocate of the wide-tele solution; Also adopts other various types of solutions.

No. of Dual-Cam Smartphones Currently On Sale: By Brand

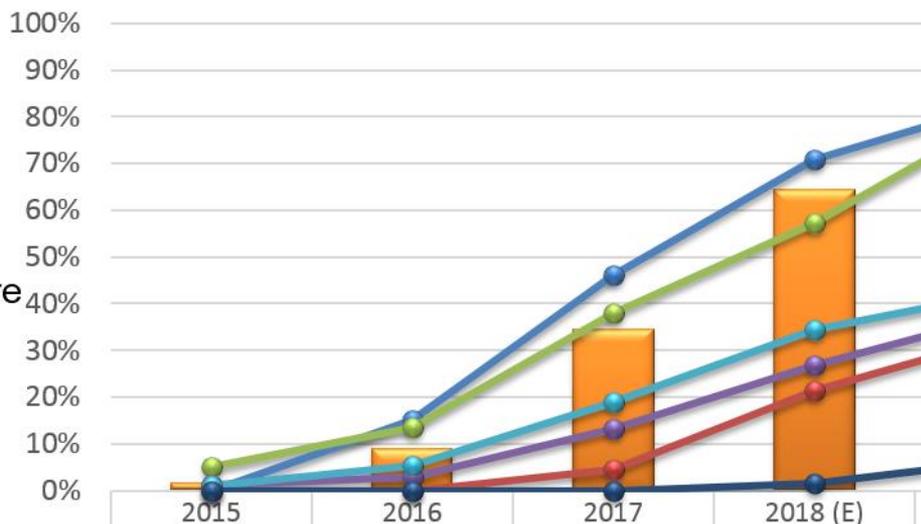
Price Range						
\$500 & up						
\$300 & \$500						
\$150 & \$300						
\$150 & below						

- Although these numbers alone don't tell much of a story, we could still sort of see which brand(s) is more aggressive in promoting dual/ tri-cam smartphones.
- Samsung has relatively few products with dual/ tri cams in spite of its complete product line that covers all different price segments.
- Although the penetration of dual-cam in mid-level smartphones keeps rising, \$150 seems to be the cut-off point for a brand to adopt this feature or not.
- Overall, these numbers suggest that dual cam is gaining momentum in mid-end phones, which is in line with what we expected.

Dual-Cam Penetration Being Substituted by Tri-Cam

■ **Dual-cam:** gaining momentum in mid-end devices.

■ **Tri-cam:** may possibly become a standard feature on flagship devices.



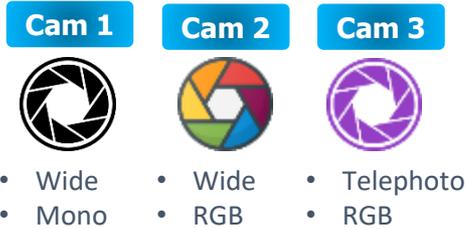
Total Global Dual Cam Units	13.4	71.6	276.2	515.6
Apple (dual-cam)	0%	15%	46%	71%
Samsung (dual-cam)	0%	0%	4%	21%
Huawei (dual-cam)	5%	14%	38%	57%
Others (dual-cam)	1%	3%	13%	27%
Total Global Dual Cam Penetration %	1.0%	5.2%	19.0%	34.3%
Total Global Triple Cam Penetration %	0.0%	0.0%	0.0%	1.6%

■ As the return of adopting dual-cam is decreasing, SP brands are migrating to tri-cam for market differentiation. We believe this will “eat away” some of dual-cam’s penetration, and therefore have downgraded our penetration forecast accordingly.

■ However, this is NOT a bad thing because the total number of cameras implemented on SPs keeps rising.

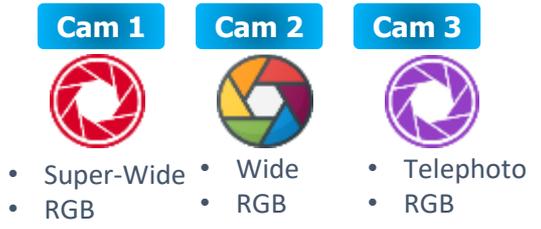
Triple Cameras: A Few Possible Configurations

1



- Combine two mainstream dual-cam configurations, allowing taking pictures in low-light while not sacrificing zoom factors.
- Large overlapping FOV between cam 1 & 2, making depth-sensing applications such as AR and bokeh appealing.
- Relatively high shutter lag during still capture and no improved low light performance during video recording.
- Power consumption can be high due to having all of the 3 cameras working concurrently.

2



- Support both high optical zoom factors AND super-wide images, which is not exactly feasible on dual-cam phones.
- With the seamless switching among each cam, this config is able to handle power consumption more economically .
- The possible downside could be the distortion caused by the super wide camera. It poses challenges for video smooth transition, image fusion, factory calibration process...etc.

3

4

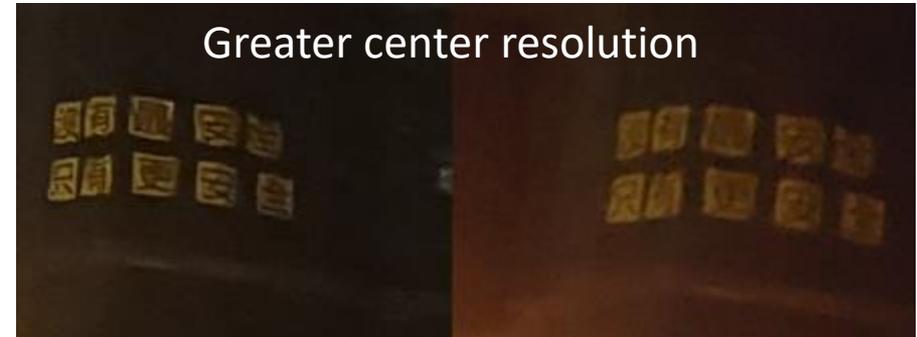
Case Study: Huawei P20 Pro

- Firstly, let's take a look at the tri-cam set-up on Huawei P20 Pro. As you can see, it follows the first type of configurations we saw earlier.
- One of the advantages of this arrangement, as we've talked about, is allowing the user to take pictures in low light while not sacrificing the zoom factor. And this is especially true for Huawei P20 Pro, which boasts a great clarity and high SNR in dark/ low light settings.
- Also, Huawei P20 Pro has impressive center resolution, thanks to its telephoto lens.



Huawei P20 Pro

iPhone X



Huawei P20 Pro

Samsung S9

- However, although Huawei tries to achieve higher zoom factors by adopting a 40 MP camera, it comes at the expense of having smaller individual pixel size, which would affect its performance in low lights.
- As a result, P20 Pro has to rely heavily on algorithms especially in low light conditions, in order to compensate for the fact that each pixel captures less light. This may cause all of its three cameras streaming concurrently, and the overall power consumption of this solution may greatly be affected.

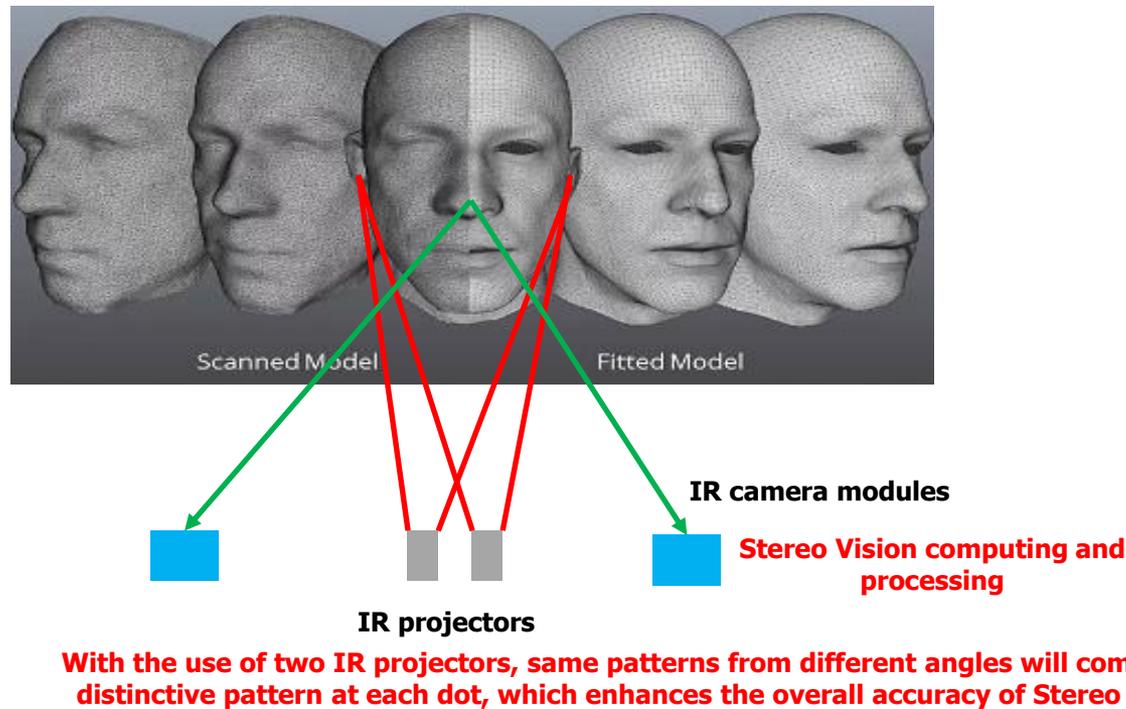
3D Sensing Solutions for Smartphones

- Smartphone brands are more positive to adopt 3D sensing on flagship products due to active of topics rather than value of functions.
- The price drop in China-made IR projectors to US\$4.5-5. But most brands still choose more expensive components suppliers such as Lumentum.
- Mask can substitute DOE in the structured-light IR projector, as in the case of Xiaomi Mi 8. But the drawback is increase in power consumption.
- The CMOS for TOF with resolutions of VGA or above, Sony's and PMD's offerings have the advantages.

Brand Company	3D Sensing Solutions								
	Structured Light				Time of Flight			Stereo Vision	
	Own solution	Qualcomm	Orbbec	Mantis Vision	Sony	Infineon & pmd	Panasonic	Intel	Megvii & Bellus3D
Lenovo									
Asus									
Apple									
HUAWEI									
Xiaomi									
OPPO									
VIVO									
Samsung									

Strategic Cooperation of Megvii and Bellus 3D

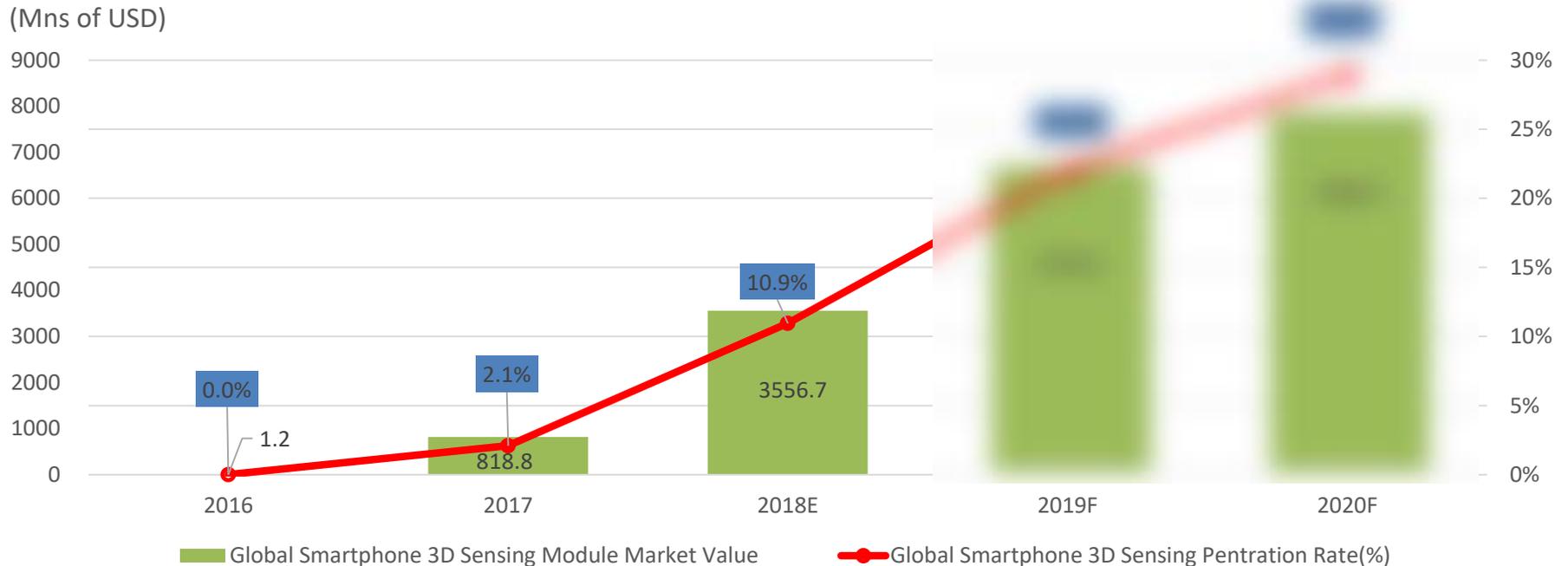
- Image recognition startup Megvii has provided OPPO and Vivo with solutions for unlocking smartphone using facial recognition. Megvii also entered strategic cooperation with Bellus3D in 2018.
- 3D sensing solutions by Bellus3D are based on stereo vision – two IR projectors emit patterns and two IR cameras to analyze the image. Advantages are fast speed and low cost. Major drawback is limited sensing range, which almost confines its use to only 3D modeling of human faces.



Source: Bellus3D, 2018

3D Sensing: More Players Have Joined the Club

- Xiaomi and OPPO have become the first in the Android camp to launch devices that embed front-facing 3D sensing modules. However, we believe the shipments of these two products (Xiaomi Mi 8 Explorer & OPPO Find X) would be very limited.
- Huawei and Samsung are expected to be the next ones to follow-suit in 2019, but similarly we expect their shipments to be low considering the cost, technological barriers and limited market demand.
- Moreover, with tri-cam becoming popular in flagship devices, we believe this trend may curb the need for SP brands to adopt 3D sensing technology.
- Therefore, we have downgraded our forecast of global 3D sensing penetration to 10.9% in 2018 and 29.1% in 2020.



Trend of 3D Sensing in Smartphone

- The cost of the 3D sensing module is still high. Even if the yield could be still improved, the price of the high-quality module may not be lower than 15 dollars, which much higher than the price of under-display fingerprints module. Therefore, 3D sensing module will still be carried in the flagship and high-end products, and it is difficult to fully spread to all models.
- Due to the existence of patents and technical thresholds, coupled with higher cost, most of brands, who choose Structure Light solution could change to Stereo Vision for face recognition to unlocking and payment in the future. As for the rear, the AR function will be mainly used, and TOF solution will be installed. It is estimated that more brands start adopting the TOF module in the second half of 2019.
- Face recognition payment requires not only accuracy of 3D sensing but also security of chips.



OPPO Find X

Structure Light in front like iPhone X

Qualcomm Snapdragon 845

Face recognition, Mobile payment

Face recognition instead of fingerprints for payment



OPPO R17 Pro

TOF Solution in rear.

Qualcomm Snapdragon 670

Environmental 3D sensing, AR function

Mobile payment with fingerprints

Source: OPPO, 2018

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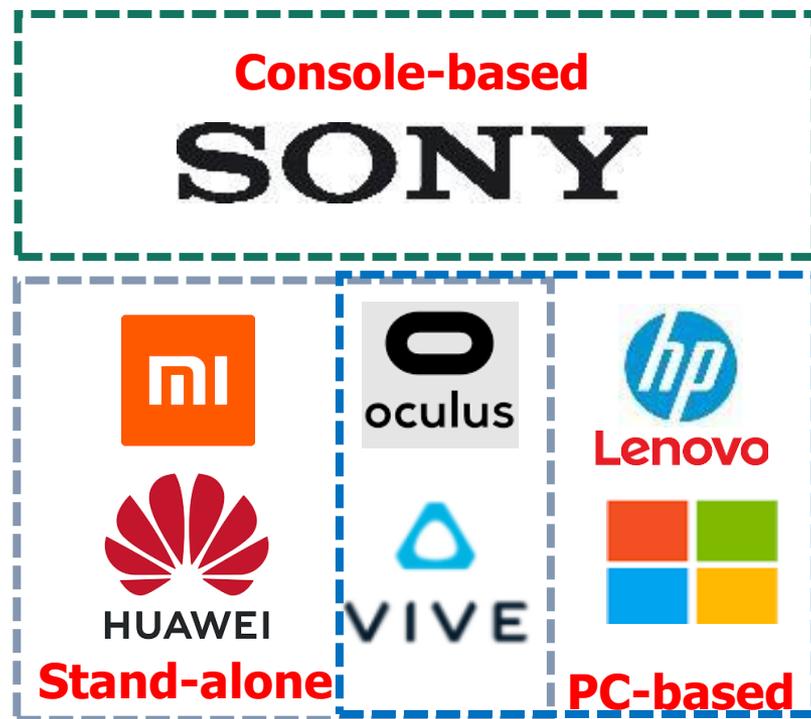
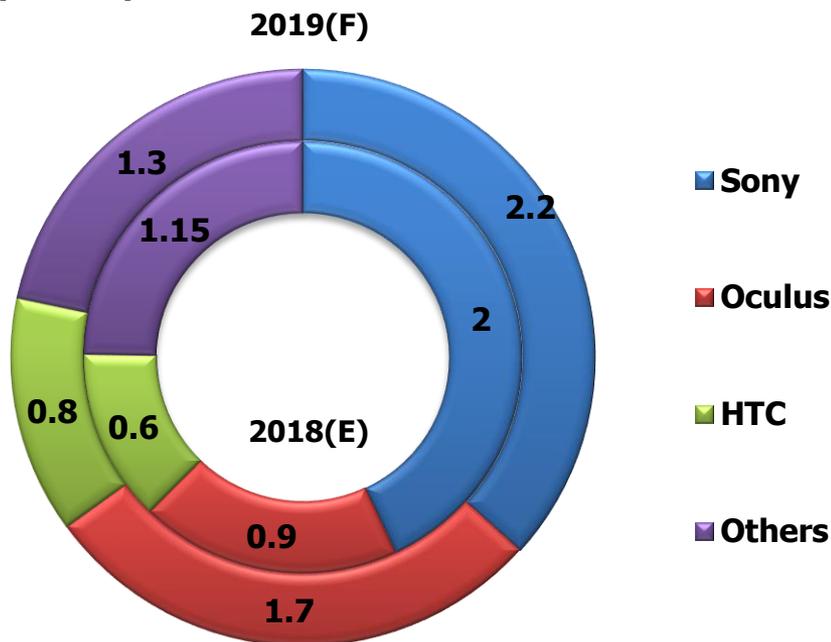
8

Summary

VR Device Shipments by Brands in 2018-2019

- Shipment target for Oculus Go may be raised due to its positive market reception, which also boosts the confidence of Oculus about the launch of Santa Cruz this October. Shipments of Santa Cruz for 2019 are forecast to total 600,000 units. This device plus VR products for low-end PCs will push Oculus's total VR shipments for 2019 to 1.7 million units.
- With its VR offerings evenly divided between the PC-based and standalone categories, HTC is expected to launch new products in 2019.
- Production has stopped for all versions of Microsoft VR (Mixed Reality Headset), except the edition for Samsung that is still being made at Goertek. The 2nd generation of this product is under development, but its production schedule is uncertain.
- Brands that have a new VR development project include JDI, Lenovo, and HP. Products from new entrants will not arrive on the market until 2019.

(M-Units)



*Does not include mobile VR devices

Smartphone Brands & Internet-Based Services Focus on Standalone VR Devices

- Application setting for standalone VR devices is similar to that for mobile devices, but most of standalone VR devices use Wi-Fi for internet connection and have to download content/services first before using.
- PC-based VR devices may consider 60GHz for wireless high-speed data transfer. However, NRE charges paid to chip makers and codec vendors could run up more than US\$ million. This plus high costs of components will constrain the adoption of wireless for PC-based VR devices within these 3 years.
- Differences in transfer speed and performances also set apart PC-based and standalone with respect to market positioning and applications. The latter will be for social networking, casual gaming, online media, and other functions that mobile devices can handle. This is also why Oculus (Facebook) prioritizes the development of standalone VR devices.

	PC-Based VR	Standalone VR
Transfer Design	Content is transferred via wire/cable	
Application Services		Casual gaming, social networking, online media
Application Setting	Similar to PCs	
Application Type	EXE	App, USDZ, Web(URL)
Main Vendors		

Amazon Sumerian

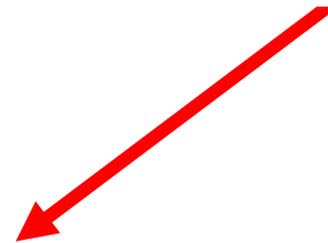
Cloud services providers



Expanding cloud-based AR/VR applications

Amazon Sumerian

The fastest and easiest way to create VR, AR, and 3D experiences

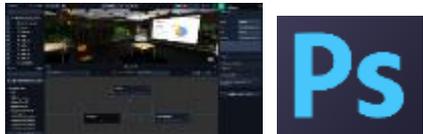


Consumers access AR/VR apps via websites

Software Remains Central in Developing AR

- AR development concentrates on software such as OS and SDK (e.g. Google's ARCore 1.0, Apple's ARKit 2.0). With slight variations, these platforms share similar development focuses: tracking, sensing & environmental analysis.
- Apple with Adobe and Pixar launched USDZ – a universal file format that allows a single file to contain everything needed to show AR effects and can be opened with a web browser. USDZ will accelerate development of AR apps and AR functions on webpages.

**AR objects (3D models)
development tools**



AR SDK



**Programming tools/
Game engine**



AR apps



USDZ AR File



Webpage editor



AR services webpages

Experts



- **Smartphone Production**

Mia Huang

- **Mobile Dram**

Mia Huang

- **NAND Flash**

Ben Yeh



- **Display**

Boyce Fan

Julian Lee



- **DDI, TDDI, Biometric**

Kurt Chen

- **Semiconductor**

CY Yao

- **Camera, 3D Sensing**

Peter Huang

Jason Tsai

- **AR/VR, Innovation**

Jason Tsai

TrendForce & TRI

Research Areas



IC



Consumer Electronics



Memory



Green Energy



LED



Display Panel



Smartphones & Apps



Automotive Technology



Cloud Computing & IoT



AI



Intelligent Living



Industry 4.0



Innovative Technology



Biotechnology & Medicine



Communication, Broadband & Networking



Digital Economy



Gov. & Ent. Consulting Service



Robots & UAVs

Sales & Services

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