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CHINA IC DESIGN SECTOR

BY.
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Semi Localization To Accelerate

We estimate that domestic IC design companies to continue to gain market share in medium term.

We believe localization, progress in technical know-how and strong policy support are the key drivers for IC design localization to accelerate.

We believe the market could overlook the opportunity of domestic IC design companies given the fundamentals of these companies are stabilizing amid recovery of global semiconductor market.

Initiate coverage on domestic CIS and AF market leader Willsemi (603501 CH) and Maxscend (300782 CH).

Initiation of Coverage

Willsemi
603501 CH

Maxscend
300782 CH

Technology Sector

Sector Rating
Outperform

7 October 2024

China IC design sector: semi localization to accelerate

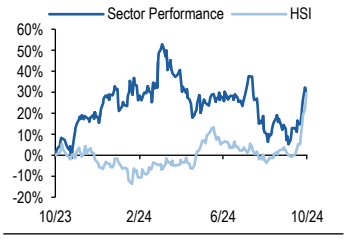
- **We initiate coverage on China IC design sector with an Outperform rating, as we estimate that domestic IC design companies to continue to gain market share in medium term**. We estimate China IC market to grow at 9.8% CAGR during 2023-2032, outpacing global IC market growth at 8.5% CAGR in the same period. We also expect domestic IC design sector's self-sufficiency ratio to improve from 18% in 2022 to 27% in 2028.
- **We believe downstream localization, progress in technical know-how and strong policy support are the key drivers for IC design localization to accelerate**. While the IC design sector spans a wide range of products and downstream applications, we like companies with large exposure to smartphone and electric vehicle due to the demand-supply cyclicity of these applications and unique position of Chinese domestic IC design companies in the supply chain.
- With Huawei's comeback in smartphone business, China domestic smartphone vendors' global market share continue to rise from 50% in 1Q22 to 56% in 1Q24, according to IDC. **Amid the recovery of global smartphone demand, we believe Chinese domestic IC design sector could be the major beneficiaries as vendors switch from foreign suppliers to domestic vendors**. While the shipment for automobile could be volatile in the short term, surge of domestic electric vehicle (EV) could benefit domestic IC design sector as more semiconductor contents are consumed by EV than ICE vehicles. Based on our comparison, we believe the technological gap between domestic and foreign IC companies is narrowing. Among different subsectors, we think CIS and RFFE are two areas where domestic players are particularly advanced in technology. We also think the competition landscape is more favorable to the CIS subsector. Domestic semi industry has been enjoying great policy and financial support and stock price typically outperforms the market after announcement of the National IC industry investment fund (Big Fund). We believe both trends could continue.
- With pullback of share prices in 2022 and relatively muted market reaction in the past 12 months comparing to their foreign peers, **we believe the market could overlook the opportunity of domestic IC design companies given the fundamentals of these companies are stabilizing.** We initiate coverage on Willsemi (603501 CH) and Maxscend (300782 CH) with **Buy** ratings due to their relatively attractive valuation and market leadership in CIS and RF space respectively. We believe developments for import substitution, upward earnings revisions and positive policy signals could be the major catalysts for stocks to rerate.

Valuation summary

Company name	Stock code	Rating	TP	CP	--------EPS-------		-------P/E-------		-------P/B-------		Yield
					FY24E	FY25E	FY24E	FY25E	FY24E	FY25E	FY24E
			(local ccy)	(local ccy)	(rpt ccy)	(rpt ccy)	(x)	(x)	(x)	(x)	(%)
AMD	AMD US	Buy	200.00	159.78	1.856	4.311	86.1	37.1	4.32	3.79	0.0
Will	603501 CH	Buy	133.00	107.20	2.906	3.796	36.9	28.2	5.34	4.60	NA
Maxscend	300782 CH	Buy	107.00	92.89	1.590	1.978	58.4	47.0	4.71	4.32	NA
Average							**60.5**	**37.4**	**4.79**	**4.24**	**0.0**

Source: FactSet, BOCOM Int'l estimates

1-year sector performance



Source: FactSet

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Executive Summary

We initiate coverage on the China IC design sector and two domestic IC design companies, Willsemi (603501 CH) and Maxscend (300782 CH). We think domestic IC design companies could benefit from downstream localization trend and strong policy support. Using our proprietary criteria, we measure subsectors and companies on their technological competitiveness/moat and downstream demand-supply dynamics. We select two subsectors RFFE IC and CMOS image sensor and initiate the coverage on their respective leaders, Willsemi and Maxscend, both with **Buy** ratings. Our bull thesis on the sector consists our views of:

(1) We realize that Chinese domestic vendors are dominating production of electronics products, including smartphones, EV, PC and servers, yet China semiconductor companies are lacking their presence in key IC components. According to Chinese custom data and WSTS, China semiconductor products imports accounts for around 70% of the global semiconductor revenue. We predict China's self-sufficiency of semiconductor production, although increased significantly from 10% in 2010 to 23% in 2023, could continue to grow to 27% in 2028. Within the semiconductor supply chain, IC design companies are among the biggest value-adders. We believe China domestic IC design companies could further benefit as downstream continues to adopt more domestic IC products;

(2) Semi localization also benefits from the global semiconductor industry upcycle in certain downstream applications. We see smartphone shipment could recover from its 2023 lows after two years of negative growth. Smartphone vendors inventory levels are down according to our analysis. Technological evolution is another driver for semiconductor demand growth. For instance, we see a long-term secular trend of more semiconductor content per vehicle as the penetration of EV goes up;

(3) We believe China's IC design companies are narrowing the technological gap with respect to global incumbents. We use power electronics subsector as an example and we believe Chinese domestic firms are catching up or even better in technology. We find similar progress made in subsectors such as RFFE and CIS in our company reports. We evaluate different semiconductor subsectors using six criteria: (i) domestic technological readiness; (ii) competitive landscape; (iii) cyclicality/downstream demand-supply dynamics; (iv) technological moat; (v) market potential; and (vi) profitability. We think domestic leaders in RFFE and CIS subsectors are well positioned to further benefit from the localization theme;

(4) We think strong policy and funding supports are the pillars for domestic semiconductor industry. We summarized state level policies, and we find the state's goal has been on reaching levels of technological sophistication for the complete IC value chain. Among policy measures, the National IC industry investment fund (Big Fund) is arguably the most direct and prominent funding support. On May 24th 2024, the third phase of Big Fund was launched with total size of RMB344bn. Our analysis shows that for the previous two phases, semiconductor stocks typically outperform the market within 24 months of the launches of the fund. We think the launch of third phase of Big Fund could be a catalyst of domestic semi stock in short term.

Will Semiconductor 603501 CH (Buy, TP RMB 133)

Willsemi is the domestic leader in CMOS image sensor (CIS) subsector and ranked No.3 with 11% of global market share after Sony and Samsung Electronics, both of which are technology conglomerates with diversified product portfolios. CIS has the highest BOM cost in a camera module, and is used in applications of smartphones, automobile and surveillance. CIS market landscape is favorable for market leader such as Willsemi since top 3 market participants have a combined market share of more than 75%. Other parts of company business include analog IC, touch and display IC and semi distribution, which together represents about a quarter of the total revenue. Major domestic smartphone OEMs including Xiaomi and Huawei and major EV companies are customers of Willsemi.

We think the most important driver for Willsemi's revenue improvement is (1) downstream smartphone vendors re-stocking CIS products as smartphone demand enters an upcycle; (2) Willsemi could grow its market share thanks to supply chain localization. We expect the smartphone market to recover in 2024 after two years of negative growth and domestic smartphone vendors could outgrow their foreign competitors. The technology gap between Willsemi and Sony/Samsung is small, according to our assessment. We predict Willsemi's market share in smartphone CIS to grow from 16.5% in 2023 to 20% in 2026. We also see more premium CIS modules being used in a smartphone upcycle, which could drive up company's ASP.

The second largest exposure to Willsemi's CIS business is the automobile industry. Our analysis shows that new EV models, including Xiaomi SU7 and Li Auto L9 Ultra, typically equip at least three times as many cameras as traditional ICE model vehicle. We also see the secular trend of autonomous driving improves demand for cameras in the future. With EV OEM being predominately domestic, we see Willsemi continues to benefit as EV penetration rises. According to Willsemi, its auto CIS shipments (in terms of number of devices shipped) ranked No.1 in the world for the first time in 1H24. We estimate that Willsemi's market share of global Auto CIS by shipment was 33% in 2023. We expect its auto CIS revenue to grow to RMB7.65bn in 2026, implying a 23% CAGR.

In the longer term, medical image and AR/VR headsets could be the new growth driver for Willsemi's CIS business. We also expect analog business to further penetrate into the domestic EV supply chain.

We initiate coverage on Willsemi with Buy rating, TP at RMB133 based on 35x 2025E P/E or 1.8x PEG. We estimate Willsemi's revenue to reach RMB26.4bn/30.5bn/33.0bn and diluted EPS to be RMB2.91/3.80/4.16 (19.6% EPS CAGR) in 2024E/25E/26E respectively. Historically, the company trades at 43.2x NTM P/E on average with a standard deviation of 15.5x. Our target multiple 35x is a discount comparing to historic average due to slower growth in recent years. As one of the largest domestic IC design companies, our target 2025 P/E at 35x is also a discount with respect to its immediate domestic IC design peers' median 2025 P/E at 46.4x. Willsemi's peers might appear to have a higher 2024 to 2026 EPS growth rate mainly due to (1) relatively smaller company size; (2) relatively lower 2024 base after recovering from semiconductor downturn. We thus think 1.8x PEG, higher than its immediate peers of domestic IC design companies' median PEG at 1.2x reflects the company's favorable market condition and industry leader position.

Maxscend 300782 CH (Buy, TP RMB107)

Maxscend designs and manufactures Radio Frequency Front End (RFFE) IC for mobile handset and other wireless products. Foreign brands used to dominate domestic RFFE market with more than 80% of market share in 2022 but that is changing driven by semi supply chain localization. As the domestic leader in RFFE IC, Maxscend's clients include major domestic and international mobile handset OEMs including Xiaomi, Huawei, Vivo, OPPO, Lenovo and Samsung. We predict Maxscend's domestic market share could increase from 2.8% in 2022 to 3.8% in 2026. Its revenue growth drivers include cyclical upturn and demand recovery for mobile handset as well as product portfolio expansion and technology improvement.

We think the company leads domestic RFFE IC vendors in technology. Maxscend ships its products in the form of discrete devices and modules. Its discrete device products, including Low Noise Amplifier (LNA) and switches are similar or better in technology comparing to global incumbents, according to our analysis. Along with the trend of global RFFE IC sector, percentage of module products relative to discrete has been increasing, and we see Maxscend making progress of ramping up new L-PAMiF and L-FEMiD module products. Company's latest module product L-PAMiD, one of the most sophisticated modules with both transmitting and receiving function, has passed qualification of major clients in 2Q24. We expect this product to contribute revenue from 1Q25.

We think investors could be overly concerned about the margin compression in recent years. To better control R&D progress and quality of the products, the company adopted a fab-lite model, in which the company has invested in two manufacturing lines for filter device and related modules. The 6-inch production line with focus on SAW (Surface Acoustic Wave) filter and modules has been ramping up in production since 2Q22. The 12-inch production manufactures IPD (Integrated Passive Device) filter and has been ramping up production since 1Q24. With the launch of latest L-PAMiD product, we expect early production ramp up to further compress GPM in 2024. We expect GPM to bottom in 2025. We believe fab-lite is strategically the right move for Maxscend to grow its revenue in the long term. Meanwhile, we think Maxscend could maintain a better margin comparing to its global and domestic peers.

We estimate Maxscend's revenue to be RMB5.1bn/6.1bn/7.0bn and diluted EPS of RMB1.59/1.98/2.56 (26.8% EPS CAGR) in 2024E/25E/26E respectively. We initiate coverage with a **Buy** rating, TP RMB107 based on 54x 2025 P/E. Historically, the company trades at 47.5x NTM P/E on average with a standard deviation of 18.8x. Our target multiple 54x P/E is higher than historic average due to our positive view on semiconductor cycle. Comparing to its immediate peers of domestic IC design companies' median 2025 P/E of 46.4x and domestic RFFE IC design companies' median 2025 P/E of 41.4x, we think company's domestic leader status, superior profitability and technological moat could justify the valuation premium.

Domestic IC design companies as a group, typically trade at a premium comparing to other semiconductor subsectors in term of P/E multiples as IC design companies operate under asset-light business model and thus have better ROE and profitability.

Valuation

Figure 1: Valuation comparison

Ticker	Name	Market cap (US$ mn)	Last price (LC)	Price ytd (%)	yoy growth of EPS (24-26E)	PE 2024E	PE 2025E	PEG 2025E	PB 2024E	PB 2025E
Domestic IC design										
603501 CH Equity	Willsemi	18,549	107.20	0%	20%	36.8	28.2	1.4	5.3	4.6
300782 CH Equity	Maxscend	7,074	92.89	(34%)	27%	58.4	46.9	1.7	4.6	4.1
688041 CH Equity	Hygon	34,203	103.28	46%	35%	136.6	99.8	2.8	11.8	10.6
603986 CH Equity	GigaDevice	8,384	88.37	(4%)	37%	52.6	35.3	1.0	3.6	3.4
300661 CH Equity	SGMICRO	6,387	95.00	7%	47%	97.9	62.6	1.3	10.6	9.3
600460 CH Equity	Silan	5,363	22.62	(1%)	75%	113.7	46.4	0.6	3.0	2.9
603290 CH Equity	Starpower	3,112	91.25	(29%)	18%	24.7	20.3	1.1	3.1	2.9
688052 CH Equity	Novosense	2,412	118.80	(29%)	N/A	N/A	195.1	N/A	2.8	2.7
688153 CH Equity	Vanchip	2,225	36.32	(45%)	33%	46.2	34.1	1.0	3.7	3.0
Median						**55.5**	**46.4**	**1.2**	**3.7**	**3.4**
Overseas IC design										
NVDA US Equity	Nvidia	2,978,923	121.44	145%	31%	42.0	29.4	0.9	30.8	16.2
AVGO US Equity	Broadcom	805,674	172.50	55%	22%	35.2	27.3	1.2	12.1	10.4
AMD US Equity	AMD	265,561	164.08	11%	47%	47.1	29.4	0.6	4.4	4.1
QCOM US Equity	Qualcomm	189,436	170.05	18%	10%	16.7	15.1	1.5	7.4	6.2
MRVL US Equity	Marvell	62,470	72.12	20%	52%	49.0	28.6	0.6	4.4	4.3
Median						**42.0**	**28.6**	**0.9**	**7.4**	**6.2**
Semi foundry										
2330 TT Equity	TSMC	783,780	957.00	61%	23%	23.1	18.1	0.8	5.9	4.8
981 HK Equity	SMIC	33,051	20.85	5%	30%	34.7	24.6	0.8	1.1	1.0
GFS US Equity	GlobleFoundries	22,359	40.25	(34%)	44%	30.7	22.1	0.5	1.9	1.7
1347 HK Equity	HH Grace	5,717	20.90	11%	65%	45.5	22.6	0.3	0.8	0.7
Median						**32.7**	**22.3**	**0.6**	**1.5**	**1.4**
Smartphone parts										
300433 CH Equity	Hnlens	14,519	20.45	55%	21%	26.2	20.4	1.0	2.1	2.0
002241 CH Equity	Geortek	11,037	22.67	8%	27%	29.5	22.3	0.8	2.3	2.2
300207 CH Equity	Sunwoda	5,826	21.96	49%	53%	25.3	19.7	0.4	1.7	1.5
2018 HK Equity	AAC	4,921	31.90	38%	(1%)	21.0	16.2	(13.8)	1.5	1.3
002456 CH Equity	Ofilm	4,692	9.95	14%	1%	57.5	36.4	63.2	7.9	7.5
300136 CH Equity	Sunway	3,198	23.20	(2%)	27%	30.5	23.2	0.8	2.9	2.6
Median						**27.8**	**21.4**	**0.8**	**2.2**	**2.1**
CMOS										
005930 KS Equity	Samsung	279,195	61,500.00	(22%)	22%	11.2	8.5	0.4	1.1	1.0
6758 JT Equity	Sony	121,159	2,777.50	4%	15%	18.3	16.8	1.1	2.3	2.0
000660 KS Equity	SK Hynix	96,661	174,600.00	23%	27%	7.0	4.5	0.2	1.7	1.3
603501 CH Equity	Willsemi	18,549	107.20	0%	20%	36.8	28.2	1.4	5.3	4.6
Median						**14.8**	**12.7**	**0.8**	**2.0**	**1.7**
RFFE										
300782 CH Equity	Maxscend	7,074	92.89	(34%)	27%	58.4	46.9	1.7	4.6	4.1
300661 CH Equity	SGMICRO	6,387	95.00	7%	47%	97.9	62.6	1.3	10.6	9.3
688153 CH Equity	Vanchip	2,225	36.32	(45%)	33%	46.2	34.1	1.0	3.7	3.0
688798 CH Equity	Awinic	1,921	57.94	(16%)	105%	66.1	35.8	0.3	3.5	3.2
688536 CH Equity	3peak	1,907	100.96	(31%)	42%	86.5	41.4	1.0	2.3	2.2
Median						**66.1**	**41.4**	**1.0**	**3.7**	**3.2**

Source: Bloomberg, Last price as of 2024/9/30

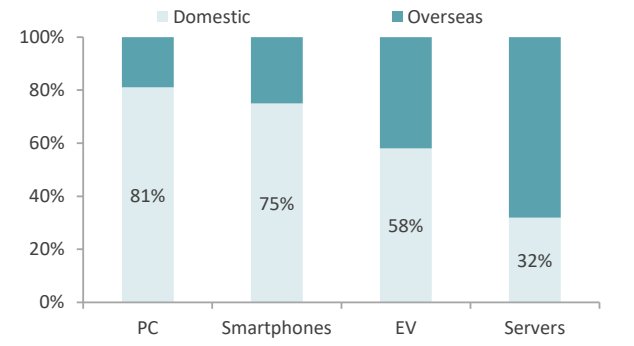
Downstream Localization Continues to Materialize, Benefiting Domestic Supply Chain

Manufacturing hub moving up in the global value chain

As one of the most important players in global technology industry value chain, China manufactures/assembles majority of electronics-related products. In 2023, almost 81% of world's personal computers (PCs), 75% of smartphones, 58% of electric vehicles (EVs) and 32% of servers are manufactured within the Chinese border, either by domestic Chinese vendors or by foreign vendors with their operations in China. Chinese manufacturing operations enjoy a complete and efficient domestic supply chain and benefits from economies of scale for most of the electronics products.

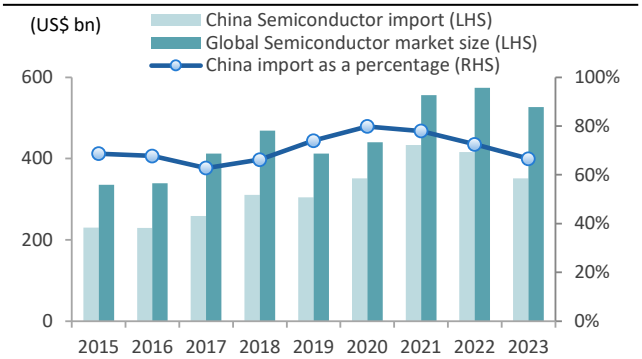
While the end products are manufactured by vendors with majority of manufacturing sites located within China, a large portion of key components, e.g., integrated circuit (IC), are provided by foreign vendors. In addition, majority of finished electronic products are consumed by overseas consumers. We think the Chinese domestic IC sector could benefit from this supply chain structure.

Figure 2: Chinese domestic vendors dominate key electronics products



Source: BOCOM Int'l estimates

Figure 3: China imports large share of Global Semiconductor products



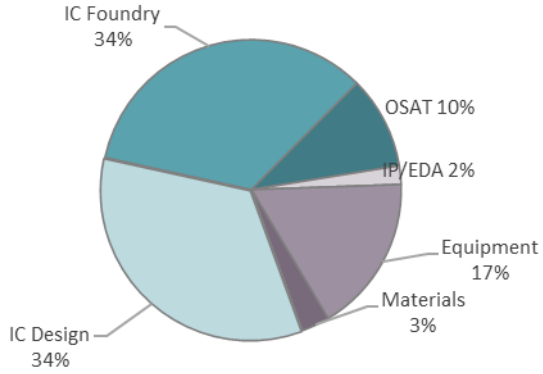
Source: WSTS, General Administration of Customs, PRC, BOCOM Int'l

According to WSTS, global semiconductor industry market size reached USD574.1/526.8bn in 2022/2023 respectively, an increase of 92.5%/76.6% comparing to USD298.3bn in 2010. According to the General Administration of Customs, China imported USD 416/351bn of the semiconductor products in 2022/2023 respectively or 73%/67% of the global semi market size. The share of Chinese semiconductor import is comparable to the share of Chinese production in some of the electronics products mentioned above. We estimate China IC market to grow at 9.8% CAGR during 2023-2032, outpacing global IC market growth at 8.5% CAGR in the same period.

IC design vital to the entire supply chain and Chinese vendors market share has high potential to grow

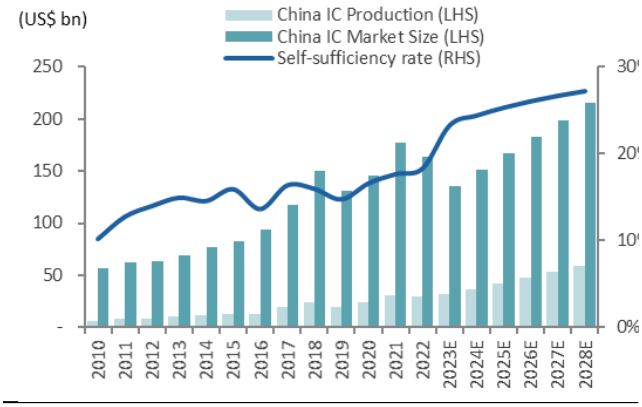
In the semiconductor supply chain (introduced in the Appendix), IC design companies (sometimes also called Fabless firms) play a crucial role of connecting downstream applications and upstream material and equipment suppliers. The innovation from IC design companies is the growth engine of the industry. When a new application/technology (e.g., Generative AI algorithms or a new generation of wireless communications standard) emerges, IC design companies are on the frontier to implement technology using microelectronics circuitry. As a result, IC design companies contribute the most valued added in semiconductor industry at 34.0% of the total value in 2023, followed by foundry at 33.5%, which drives the industry by providing finer and more powerful ICs.

Figure 4: IC design contributes significant value in the semiconductor industry



Source: BOCOM Int'l estimates

Figure 5: China semiconductor self-sufficiency rate could continue to surge



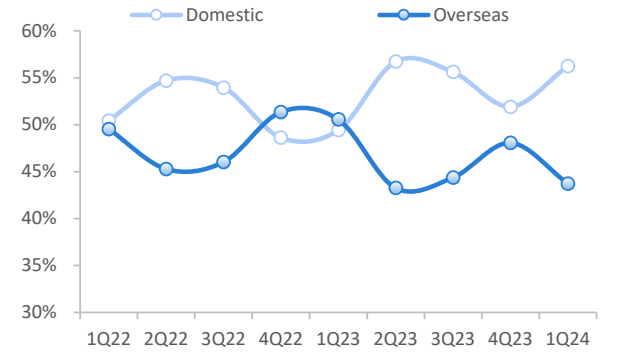
Source: TechInsights, BOCOM Int'l estimates

From an economic development and national security perspective, the importance of semiconductor self-sufficiency should never be underestimated. From 2010 to 2023, the self-sufficiency rate (defined as the ratio between China IC production and IC product consumed by the domestic market) of the China's semiconductor industry has risen substantially from 10% in 2010 to 24% in 2023, or 14 ppt in 13 years. The self-sufficiency rate slightly dropped in 2018 and 2019 before it strongly rebounded in 2020. In 2022, although Chinese domestic semiconductor demand decreased due to the cyclic downturn of global semiconductor industry, China semiconductor self-sufficiency rate has shown resiliency, improving from 15% in 2019 to 18% in 2022. To achieve higher self-sufficiency, Chinese IC design companies are poised to catching up with their global peers as technology continues to evolve. We estimate that China's semiconductor self-sufficiency to achieve 27% in 2028.

Chinese brand gaining market share in key downstream applications

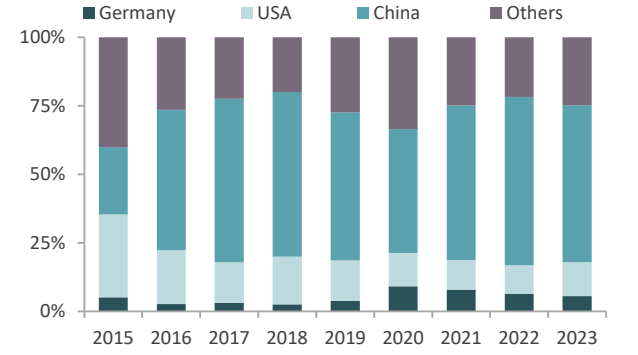
One of the key drivers for domestic IC design companies to gain market share is the fact that Chinese domestic vendors are playing an even more important role in downstream applications.

Figure 6: Smartphone vendors market share: domestic vs overseas



Source: IDC, BOCOM Int'l

Figure 7: Chinese share on global EV production could continue to expand



Source: Marklines, Bloomberg, BOCOM Int'l

Taking the smartphone space as an example, according to IDC, domestic smartphone vendors, including Vivo, OPPO, Xiaomi and Transsion make up more than 50% global market share. Despite some market share volatility in part of 4Q22 and 1Q23, Chinese vendors' combined market share rise materially in 2Q23, partly driven by the return of Huawei and better competitive advantages of other Chinese Domestic OEMs. In 1Q24, domestic brands' market share has risen to 56% at the expense of foreign brands.

Similarly, Chinese domestic manufacturers have shown great competitive advantage in EV sector. In 2015, only 25% of the Global BEV sales are made by China domestic EV producers. Led by domestic sector leaders, such as BYD, Li Auto and NIO, Chinese domestic OEMs in 2023 contribute 57% of global EV production, outperforming their US and German counterparts.

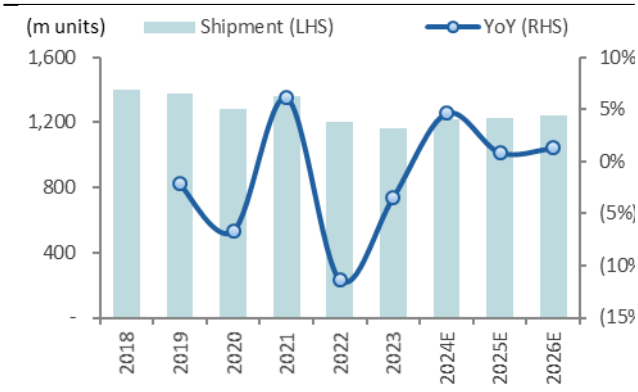
While domestic smartphone and EV vendors would like to achieve supply chain diversification, we believe they also tend to prefer domestic supply chain partners over foreign ones given comparable technological sophistications. We think this is mainly due to: a) Domestic suppliers provide better communications and technical support than their foreign peers; b) Domestic components are in general more competitive in terms of value for money; c) Domestic partners provide better supply chain security.

We believe that Chinese domestic IC design companies are the major beneficiaries as downstream localization continues. We predict that upstream high value-added IC design sector to follow the course of localization and estimate that domestic IC production to achieve USD58.4bn of sales in 2028, 86% higher than USD31.4bn in 2023, or 13% CAGR in this time span. In the long term, we also believe that when new downstream technology emerges, Chinese domestic IC design companies might further benefit should a domestic OEM becomes the major vendor of the electronics hardware.

Smartphone sales to recover while vehicle electrification trend might continue

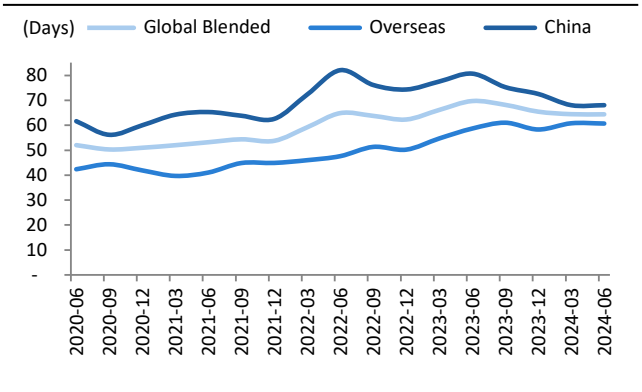
Along with the secular trend of semiconductor supply chain localization is the cyclic upturn of some key downstream applications such as smartphone and PC/servers, which could also benefit domestic IC design companies with exposure to the smartphone applications. According to IDC, global smartphone shipment rebounded in 2021 after consecutive years of negative growth amid global semiconductor shortage. Yet, shipment decline 11% and 3% YoY respectively in 2022 and 2023, partly due to global macro uncertainty and inventory destocking. Based on strong YTD numbers from IDC, we predict that the smartphone shipment could grow 6% in 2024, mainly driven by the replacement cycle and inventory restocking. Looking forward, generative AI on the edge could be a driver for further shipment growth, although the visibility of AI phone adoption is still limited.

Figure 8: Smartphone shipment set to recover



Source: IDC, BOCOM Int'l estimates

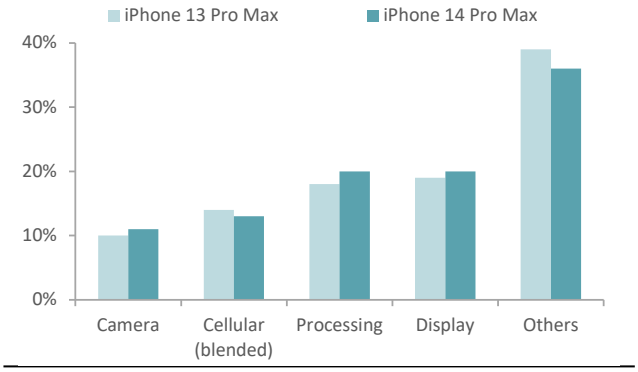
Figure 9: Average inventory level of global smartphone vendors is falling



Source: Bloomberg, Apple, Samsung, Transsion, Xiaomi, BOCOM Int'l

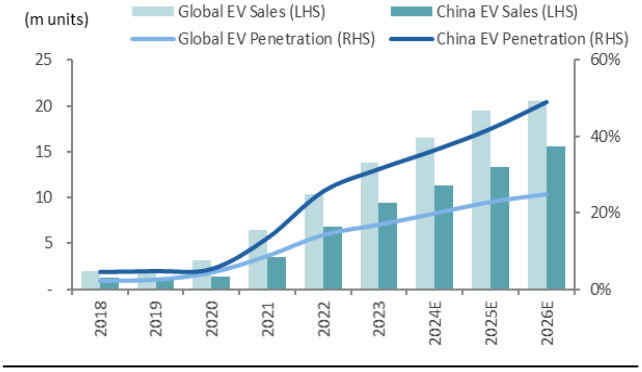
We estimate global smartphone shipment to grow moderately at 1% in both 2025 and 2026 YoY. With respect to smartphone supply chain, we believe we are in the relatively early stage of an upcycle. We look at the days of inventory for major domestic (Xiaomi, Transsion etc.) and global (Apple, Samsung) smartphone OEMs and we see the average inventory levels rose from 1Q21 until 3Q23 and have been decreasing for 3-4 consecutive quarters. While the inventory levels are coming down from its peak, they are still materially higher (global blended 68 days) than the previous lows (50 days) in 2020. As the inventory levels of smartphone vendors are coming down, we could see vendors more aggressively procure components in the next 12-18 months. We think there is still room for inventory levels to improve. Upstream suppliers, including IC design companies, could benefit in this process. Among different smartphone vendors, Chinese vendors are drawing down their inventory more aggressively than their foreign peers, which could further benefit Chinese local suppliers, in our opinion.

Figure 10: BOM cost percentage in a smartphone



Source: TechInsight, BOCOM Int'l

Figure 11: Vehicle electrification trend accelerates



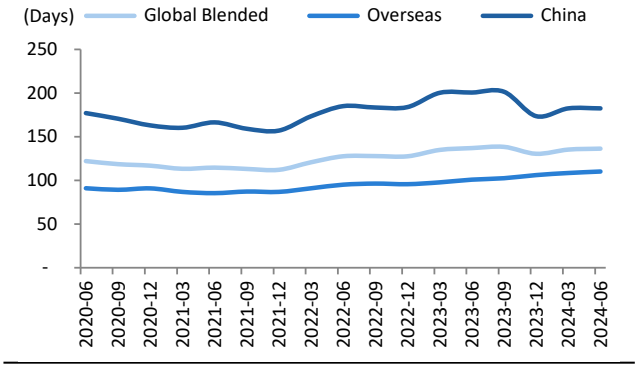
Source: Marklines, CAAM, BOCOM Int'l estimates

Regarding the key components of smartphone, we study the BOM (bill of material) cost of Apple's iPhone. According to TechInsight, modules of camera, cellular (wireless), processing and display accounts for 11%, 13%, 20% and 20% respectively of BOM cost, although there is slight disparities among different iPhone models. We thus believe, upstream suppliers with exposure to the abovementioned parts, including Willsemi (camera/CMOS image sensor or CIS) and Maxscend (Radio Frequency Front End RFFE/wireless) are in a position to further capture the localization trend.

The use of camera (CIS) and wireless (RFFE) modules are also increasing while the automobile industry is making transition from ICE vehicle to EV. According to the China Association of Automobile Manufacturers (CAAM), China's EV penetration rate exceeds 31% in 2023, which we expect to climb to 49% by 2026E. Globally, we expect EV penetration to rise from 17% in 2023 to 25% in 2026E. Proliferation of EV could drive up the demand of semiconductor devices. Electric/Electronics content in an EV is 59% comparing to only 15% in an ICE vehicle according to Gasgoo.

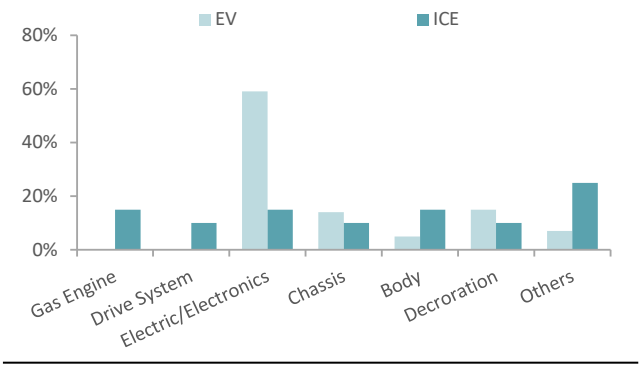
We study the inventory days for major 20+ major domestic (including Joyson Electronics (600699 CH) and Desay SV Automotive (002920 CH)) and foreign (including Siemens (SIE GR) and Honeywell (HON US)) automobile/industrial companies. Similar to other downstream applications, demand for semiconductor related products is generally weak since 2H21 and average inventory level has been trending up. In 2H23, we see inventory levels showed some signs of going down but subsequently rebounded in 1H24 as the demand recovery was not sustainable. Foreign IC companies with exposure to auto and industrial, including Texas Instrument (TXN US) and On Semi (On US) all reported disappointing results in 1H24.

Figure 12: Average inventory days of global industrial and auto vendors remain elevated



Source: Bloomberg, Joyson Electronics, Siemens, Texas Instrument,BOCOM Int'l

Figure 13: Electronics component in EV higher than ICE vehicles



Source: Gasgoo, BOCOM Int'l

Although demand for auto and industrial related IC products have been experiencing some cyclical downturn globally in 2024, we see the secular trend of utilizing more ICs in automobile irreversible, especially in China. Faster penetration of Chinese domestic EV market and outperformance of Chinese EV OEMs could also stimulate strong demand for domestic camera/CIS and wireless/RFFE ICs as we articulate in Maxscend and Willsemi's initiation reports.

Technological Gap Narrows, CIS/RFFE in Sweet Spot

We think one of the major drivers for Chinese domestic IC design sector has been the continual technology upgrade. We use the subsector of insulated-gate bipolar transistor (IGBT, a type of power electronics) as an example to illustrate the catch-up efforts of Chinese domestic IC sectors. We also have a technological comparison and analysis for RFFE and CIS IC in Maxscend's and Willsemi's initiation reports, respectively. On the other hand, we see competition has intensified in some IC design areas amid the cyclical downturn of the global semiconductor industry. We present a score card for different domestic IC design subsectors. We argue that CIS and RFFE are well positioned with a good balance of technology upgrade, demand-supply dynamics and competitive landscape.

Chinese IC design companies catching up in technology

Due to its strategic importance, global competition in semiconductor industry has intensified in recent years. We see China's IC design companies catch up in technology. Some Chinese domestic players are now in parallel with, if not more advanced than, foreign counterparts in technological sophistication.

We present a case study in power electronics (IGBT circuit) to illustrate the catch-up progress of Chinese domestic IC design companies in recent years. We also compare the technological progress of RFFE and CIS IC in our stock initiations respectively.

Our conclusion: In power electronics, Chinese players possess comparable technology with global market leaders. In RFFE IC, Chinese market leaders are catching up in both modules and discrete devices, and can compete in most of the product categories. Should they manage to develop more high-end products, they could gain more market share from global incumbents. For CIS IC, we think Chinese domestic leaders are very close to the global leaders in terms of product sophistication.

In addition, Chinese domestic players are ready to compete in the areas of NOR flash memory, MCU/MPU and sensors. In areas such as ASIC/FPGA, general computational logic and high-end DRAM including HBM, we think there are still technological gaps for Chinese domestic players to close.

Case study: China's advances in power electronics

With applications in new energy vehicles (NEV), rail transit, wind power system and solar panel sectors, power electronics was an area dominated by foreign suppliers two decades ago. The role of power electronics is to control/rectify/change the voltage, frequency and direction of current in high-voltage electric system.

We investigated the product roadmap of Infineon (IFX GR), the global market leader in IGBT IC, a type of power electronics, for the past 35+ years. From the first generation of IGBT 1 developed in 1988, Infineon has led the IGBT sector with seven generations of new IGBT products. Key technology changes include IC structure change from first-generation Punch Through (PT) to second-generation Non-Punch Through (NPT) in 1997, to Trench

Field Stop as the major structure in the 21st century. Most recently, Infineon launched IGBT 7 with Micro Pattern Trench (MPT) Field Stop structure, which provides better performance optimization compared to the previous six generations. Major technical parameters such as junction temperature and short circuit time have all undergone upgrade in the technology evolutions.

Figure 14: Infineon technical parameters from IGBT 1 to IGBT 7

IGBT	Launched in	Structure	Junction temperature (℃)	Short circuit time (μs)	Encapsulated in
IGBT 1	1988	PT			Module
IGBT 2	1997	Planar + NPT	125	10	Module
IGBT 3	2001	Trench Field Stop	125-150	6-10	Module
IGBT 4	2007	Trench Field Stop	150	10	Module
IGBT 5	2013	Trench Field Stop + CCL	175	10	Module
IGBT 6	2017	Trench Field Stop	175	3	Single chip
IGBT 7	2018	MP (Micro-Pattern) Trench Field Stop	Overload 175	8	Module

Source: Infineon, public data, BOCOM Int'l

China's domestic IGBT sector, starting from much behind its foreign peers, has emerged rapidly to fulfil the large demand from downstream sectors. We studied the product roadmap of StarPower (603290 CH), a domestic IGBT leader. We think that the company has achieved a technological sophistication similar to the global market leader Infineon. Founded in 2005, 17 years later than Infineon's first generation of IGBT product, StarPower developed its first Planar-based NPT product in 2011. The product development accelerated after 2015 when the company successfully developed Trench Field Stop-based IC for industrial and NEV applications. The applications of StarPower's products quickly spanned to areas such as rail transit, photovoltaic and wind power around 2019. Meanwhile, the company developed its own IGBT manufacturing capability and eventually developed the world's most advanced MPT field stop-based IGBT in 2021. In summary, StarPower spent only around 10 years to catch up with the 30-year product development cycle of Infineon.

We attribute the success of domestic IC design companies to the fact that downstream vendors, especially some newly emerged industries, are predominantly domestic players and thus would prefer to utilize more domestic products.

As an example, with the rapid growth of China's EV sales since 2016 and penetration rate at about 40% at present, Chinese IGBT manufacturers, led by BYD Semiconductor and StarPower, have taken advantage of the trend of vehicle electrification to stand out and gain market share in this field. Domestic EV OEMs have accelerated supply chain localization. According to JW Insights, before 2021, foreign IC companies had 80-90% share in the domestic EV and storage-related IGBT market. With supply chain localization, domestic IGBT vendors, led by BYD Electronics and StarPower, have 30-35% after 2022.

We also see similar trend in the field of industrials, where Inovance (300124 CH) emerged as a domestic leader of industrial robots and automation components. Its suppliers include StarPower and Macmic (688711 CH), and Silan (600460 CH) quickly ramped up shipment in industrial-related IGBT.

Figure 15: StarPower catching up in technology

Milestone	Product	Applications	Progress
2011	Planar+NPT	Industrial/NEV	First developed NPT based chip in 2011
2015	Trench Field Stop	Industrial/NEV	First developed Trench Field Stop chip in 2015
2019	Trench Field Stop	NEV	650-750V product ramped up in NEV
2019	Trench Field Stop	Rail transit	3300-6500V product first deployed in railway applications
2020	Trench Field Stop	Photovoltaic	1200V product first developed for photovoltaic application. The chip was manufactured on 12-inch production line.
2020	Trench Field Stop	Wind power	1700V product first developed for wind power application. The chip supports fast recovery mode.
2021	Trench Field Stop	NEV	Introduced 800V-1200V main motor controller
2021	MPT Field Stop	NEV	First introduced 650V/750V/1200V MPT Field Stop chip
2022	Trench Field Stop	Wind power	Full-platform IGBT products are mass-produced on 12-inch production line, covering 650V-1700V
2022	MPT Field Stop	Wind power	First introduced 1200V MPT Field Stop for wind power application
2023	MPT Field Stop	NEV	750V product achieved mass production. 1200V product is qualified for major auto OEM. Added 800V product in the NEV product line.
2023	MPT Field Stop	Photovoltaic	First introduced MPT Field Stop based for photovoltaic application

Source: StarPower, BOCOM Int'l

Comparing of semi subsector and domestic capabilities, we believe CIS and RFFE are sweet spots

While domestic players have made great technological strides in different IC design subsectors, we think the market dynamics in some areas have turned unfavorable for domestic players recently due to: (1) stiff competition among domestic players and with international players; (2) excess capacity and weakened pricing power for domestic IC design companies; (3) cyclical downturn in global semiconductor industry for certain IC products and unfavorable demand-supply dynamics for IC design companies.

We like Chinese domestic players in general, but investors should be selective with IC design stocks. We think domestic CIS and RFFE design leaders are well-positioned in the current market environment to achieve long-term sustainable revenue and earnings growth. We initiate coverage on Willsemi and Maxscend based on their leadership status in their respective subsectors and current market dynamics.

We have compiled a score card assigning a score from 1 to 5 to different IC subsectors in six criteria: domestic technological readiness, competitive landscape, cyclicality (downstream demand-supply dynamics), technological moat, market potential and profitability. For each criteria, a higher score means the market is more favorable for the IC design companies.

Adding up the scores for each IC design subsector, we found that general logic IC has the highest score, largely due to its high technological moat, favorable market potential and profitability. However, we are cautious on domestic players' technological readiness, especially for the listed domestic IC design companies. CIS and RFFE both score high as these two subsectors have the proper balance between domestic technological readiness, downstream demand-supply dynamics and market potential.

Figure 16: Score card of China domestic IC design subsectors

	Domestic technological readiness	Competitive landscape	Downstream demand-supply dynamics	Technological moat	Market potential	Profitability	Total score
ASIC/FPGA logic	2	3	2	4	3	3	17
CMOS image sensor	4	4	4	3	4	4	23
General logic	2	4	4	5	5	5	25
General sensor	4	2	3	2	2	3	16
MCU/MPU	5	1	2	2	2	2	14
Memory DRAM/HBM	2	4	4	4	4	3	21
Memory NAND	3	3	3	3	2	2	16
Memory NOR	4	3	3	3	1	2	16
Other discrete device	3	2	3	2	4	3	17
Power device	4	2	2	3	3	2	16
Power IC	4	2	2	2	3	2	15
RFFE	4	3	4	4	4	4	23

Source: Public data, BOCOM Int'l

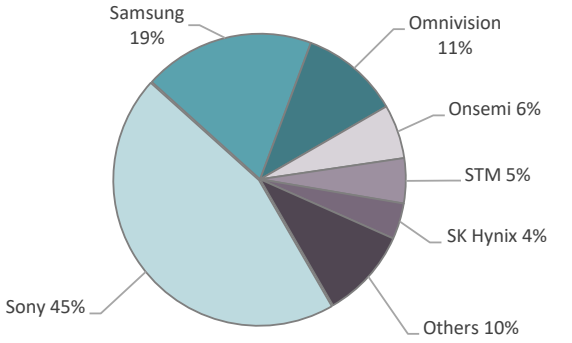
Domestic technological readiness

We assessed the technological sophistication of domestic IC design subsectors. We think domestic players have closed the gap in areas such as MCU/MPU and power IC/device (as illustrated previously), and are still lagging behind in areas such as general logic, ASIC/FPGA and HBM. While it is quite difficult to quantify the gap, we compared the product line and performance for RFFE and CIS (see Maxscend and Willsemi initiation reports). Our conclusion is that for both subsectors, although Chinese domestic vendors might not have some of the most state-of-the-art technologies, the technological sophistication has been very similar to the global incumbents.

Competitive landscape

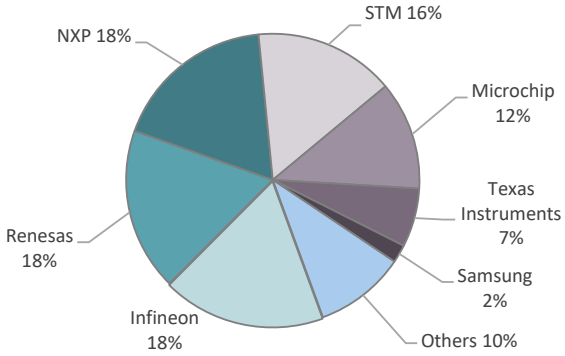
We think markets for subsectors such as CIS and general logic are fairly concentrated, creating a relatively healthy competitive landscape for market leaders. Take the market structure for CIS as an example, the top three players Sony, Samsung and OmniVision (a subsidiary of Willsemi with 100% control) each had a global market share of 45%, 19% and 11% in 2023, respectively, corresponding to an HHI of at least 2507. On the other hand, due to its low barrier of entry and heterogeneous technology, MCU market is much more fragmented. The top three players Infineon, Renesas and NXP all had 18% of the global market in 2023, according to Yole, corresponding to an HHI of less than 1500. Market for RFFE is also concentrated (see our initiation report), and we predict that competition in RFFE and CIS subsectors is driven more by technological upgrade and innovation than price war.

Figure 17: Global CIS market share (2023)



Source: Yole, BOCOM Int'l

Figure 18: Global MCU market share (2023)

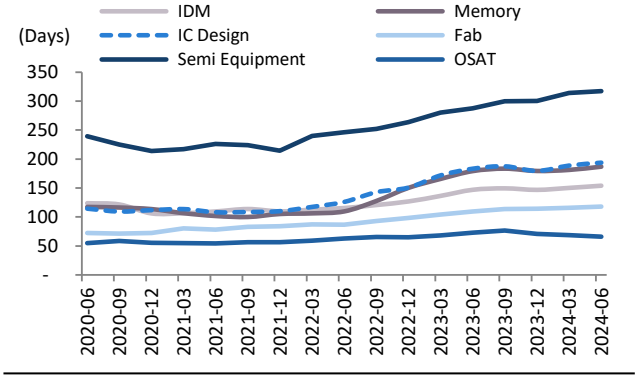


Source: Yole, BOCOM Int'l

Cyclicality (downstream demand-supply dynamics)

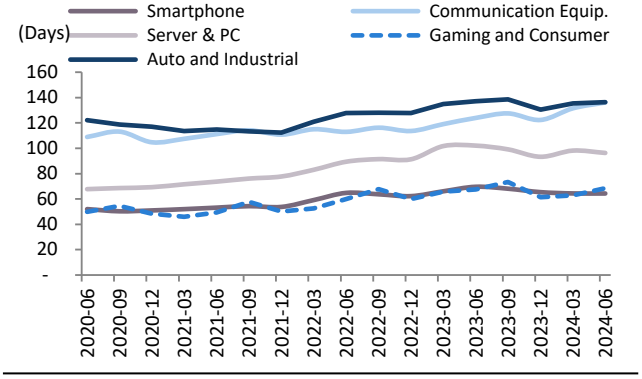
Since 2H22, global semiconductor industry has entered a cyclical downturn due to oversupply in 2020-22 until recently, when some applications have shown signs of recovery. We studied the downstream demand cycle and examined the current demand-supply relations for different semiconductor product categories. We think IC design subsectors with exposure to smartphone and server/PC, such as CIS and RFFE, could benefit when these applications embark on an upcycle.

Figure 19: Inventory days of China domestic downstream applications



Source: Bloomberg, BOCOM Int'l

Figure 20: Smartphone and server/PC Inventory days drop recently



Source: Bloomberg, BOCOM Int'l

By analyzing the inventory days of 50+ China domestic and 100+ global downstream companies, we think the inventory levels of applications such as smartphone and server/PC have bottomed. Average inventory level for domestic **smartphone** supply chain companies, including Xiaomi and Transsion, has dropped to 68 days in 2Q24 compared to 82 days in 2Q22. Globally, average inventory level for smartphone OEMs peaked in 2Q23 at 70 days and dropped to 64 days in 2Q24. Driven by strong demand from generative AI applications in the cloud and on the edge, **server/PC inventory** peaked in 2Q23 at 102 days and fell to 96 days in 2Q24. HBM memory, general logic, CIS and RFFE have large exposure to these two applications.

On the other hand, **auto/industrial** demand has weakened in both China and globally. Global average inventory level for auto/industrial companies including Cummins, Keysight and Magna has been rising since 4Q21. In China, inventory level rebounded in 2024 after showing some early signs of recovery in 2H23. We think this is mainly due to industry oversupply in solar panel and EV in the past couple of years. Due to a lack of technological upgrade, communication equipment demand is muted. We thus think IC design companies with exposure to these applications, such as ASIC/FPGA and power electronics, could face pricing and volume pressure in the near future.

Technological moat

A higher technological moat provides subsector leaders with the capability to defend or consolidate market share in an upcycle and prevents price war in a downcycle. We think subsectors like general logic and ASIC/FPGA logic are of high moat, as IC design companies increasingly utilize software capability to complement hardware functions. We also think advanced DRAM such as HBM are hard for competitors to enter, as the technology of advance packaging is still in the early stage and very limited players are capable of applying the technology in mass production. Yet, a lack of domestic competitiveness makes us cautious towards domestic leaders in these areas in the near term.

We also think the moat for RFFE subsector is trending higher, as global market leaders Qorvo and Skyworks as well as domestic leader Maxscend adopt a trend of integrating IC manufacturing with their designing work. This practice could allow IC design companies to better control and customize their R&D (see our discussion on Maxscend's fab-lite model in initiation). CIS design could also be challenging as the dimension of the sensor continues to shrink and advanced algorithms are involved in the CIS module. We find technological moat for subsectors such as MCU/MPU and power electronics relatively moderate.

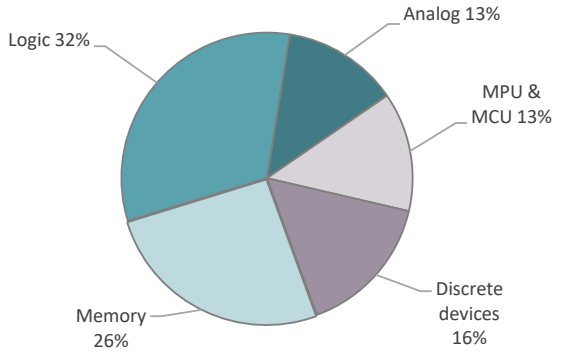
Market potential

With respect to market potential, we primarily investigate the current market size and growth outlook of the subsector. As the Chinese domestic IC design companies' market share is generally low, and Chinese domestic vendors market share on downstream applications are generally high, we believe the global IC subsector's market size is good proxy for Chinese domestic IC design companies' potential for domestic substitution. In other words, we treat the global IC subsector's market size the same as addressable market for Chinese domestic IC design companies as the Chinese domestic vendors' market share for different subsectors is high. Instead of focusing on cyclical aspects of the IC market, which are affected by the short-term demand-supply dynamics, we estimate the growth outlook for different subsectors for the next 10 years, which is mainly driven by the secular growth of technology.

According to our estimation, global market size for logic IC, memory IC, analog IC, MCU/MPU and discrete IC were US$200bn/160bn/80bn/82bn/98bn in 2023 respectively (see Appendix). We estimate a CAGR of 9.8%/5.8%/7.5%/6.5%/9.6% for these five subsectors from 2023 to 2033 respectively. We think logic IC could outpace other subsectors due to strong computation demand from generative AI. For subsectors such

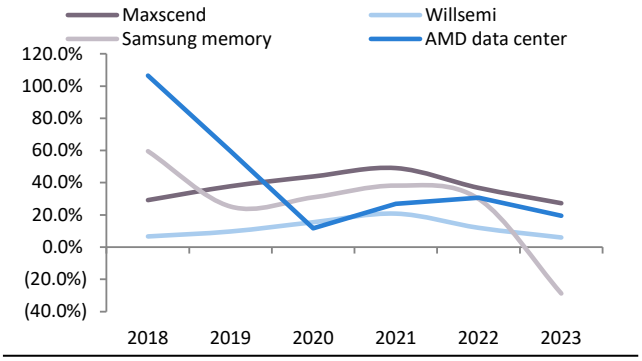
as NOR flash memory, as the downstream application is niche, we think the growth could be slower than that of memory IC. We estimate the growth for MCU/MPU to be relatively low mainly due to ASP concerns as competition intensifies. CIS and RFFE ICs are in the category of analog IC, whose growth is in the middle of the pack, in our opinion. Analog IC could benefit from large technological upgrade such as new WLAN or cellular standard upgrade in the next 10 years, although our visibility is low now. We think general logic IC and DRAM/HBM are superior among different IC subsectors due to our optimistic view on the long-term secular growth outlook driven by generative AI.

Figure 21: Global semiconductor market by product category



Source: Market.us, BOCOM Int'l

Figure 22: OPM Comparison- CIS and RFFE IC margin less volatile



Source: VA, BOCOM Int'l VA consensus for Samsung and AMD

Profitability

We believe profitability is a comprehensive measure of subsectors' competitive landscape, innovation progress and cyclical dynamics. Even though company/ sector's short-term profitability could fluctuate, we think the score should reflect whether the subsector could consistently provide steady cash to the shareholders in long term.

We examined the OPM of the subsectors leaders, and we think domestic CIS and RFFE's OPM are less volatile than the market leaders of some other subsectors except for general logic. More specifically, Maxscend's OPM fluctuated at 27-49% between 2018 to 2023. Willsemi's OPM, although much lower, was consistent in the range of 6% to 21%. On the other hand, OPM for memory vendors are much more volatile with Samsung's memory OPM fluctuating between -29% and 60%. We assign higher score to high-margin subsector with less volatility.

In summary, our study from six aspects of different of IC subsectors suggests that **CIS** and **RFFE**, although not the most lucrative in market potential, have a relatively healthy competitive environment for domestic market participants. Both subsectors have large exposure to smartphone applications, which we believe is in a cyclical upturn. Domestic players' technological readiness is also sophisticated to allow market leaders to reach the goal of localization in the near term.

Policy and Funding Support Boost Investor Confidence and Could be Stock Catalyst

We think IC design companies play a vital role in the semiconductor supply chain. The key tasks of IC design companies include: (1) designing integrated circuit systems to efficiently and effectively address the needs of applications; (2) collaborating with industry partners, including IP/EDA vendors, IC foundries, semiconductor equipment vendors, OSAT (outsourced semiconductor assembly and test) and software companies, to implement and manufacture the design. We think policy and funding support from the state to local governments to the IC design companies could foster a more capable ecosystem from upstream to downstream. We see consistent policy support from top-level decision-making bodies, including the establishment for three phrases of National IC industry investment funds. Phase III of the fund, launched in May 2024, could be catalyst for domestic semiconductor stocks. Historically, domestic semiconductor stocks outperformed the broad indices in the two years after the launch of previous phases of the fund.

Semiconductor: policy focus on modernizing domestic supply chain

To pursue semiconductor self-sufficiency, there has been a series of government policy emphasizing catch-up in different parts of semiconductor supply chain. Summarizing the state-level documents in the past decade, we see two specific goals of the government: (1) ultimately, to build a complete semiconductor supply chain from upstream semiconductor materials to downstream applications, emphasizing completeness/ independence in funding and support; (2) to support the broader development of the technology industry with the said semiconductor supply chain. As the most fundamental building block of the tech supply chain, the semiconductor industry is critical to applications such as AI and quantum computing. Also, we see the areas of applications mentioned in government documents evolve along with global technology developments.

To build a complete supply chain, the government has goals for each part of it. For IC design, the goal has been to improve the quantity and quality of intellectual property and technical know-how for different types of ICs. Critical IC types include MCU, RFFE and CIS mentioned in this report, and in more sophisticated areas such as general-purpose computing. For IC manufacturing/fabrication, before 2019, the goal was for China to achieve a certain level of global market share in specific nodes. Although not mentioned in documents after 2020, we believe this goal remains. We also believe yield and efficiency are key metrics for domestic fabs when developing different generations of processing technologies. For semiconductor equipment and software designing tools, the goal is to have a higher percentage of domestic IC design and manufacturing companies to adopt domestic tools.

When it comes to areas of applications, we see policies not only emphasize the areas in which nations are competing, such as 5G/6G and AI, but also where Chinese domestic

supply chain has advantage, including power electronics. Emerging applications such as brain science and quantum computing are also in focus.

The forms of support include (a) promoting and protecting IPs; (b) support in taxation/ land/credit and setting up favorable conditions for private sector investment; and (c) direct government funding support.

More specifically, government plans such as “Made in China 2025” and “Action Plan for Steady Growth of Electronic Information Manufacturing Industry from 2023 to 2024” provide financial and non-financial incentives on talent acquisition and IP application. In terms of taxation and credit, the “Notice of Taxation on Enterprise Income Tax Policies for Integrated Circuit Manufacturing Enterprises” issued by the Ministry of Finance in 2018 reduces enterprise income tax by half for qualified integrated circuit manufacturing enterprises. In 2023, “Notice of the Ministry of Finance and the State Taxation Administration on the Policy of Value-added Tax Deduction for Integrated Circuit Enterprises” allows enterprises engaging in IC design, production, OSAT, equipment and materials to further reduce VAT payable by 15% from 1 January 2023 to 31 December 2027. Regarding private sector investment, "Policies for Promoting the High-quality Development of Integrated Circuit Industry and Software Industry in the New Period" in 2020 provides incentives to deepen international cooperation, enhance industrial innovation ability and development quality. Similar supports on finance, investment and financing, research and development, import and export, talent, intellectual property rights, market application and international cooperation are also announced in the same policy document.

Figure 23: China semiconductor related policies

Time	Issuing authority	Policy	Content
2014/6	The State Council	Outline for Advancing the National Integrated Circuit Industry	By 2015, the revenue of the IC industry should exceed RMB350bn. The 32/28 nanometer (nm) manufacturing process should achieve mass production, and the revenue of high-end packaging and testing should account for more than 30% of the total packaging and testing industry sales. 65-45 nm semiconductor equipment and 12-inch silicon wafers should be applied in the production line. By 2020, the aim is to achieve >20% average annual growth rate of revenue of the industry. The 16-14 nm manufacturing process should achieve mass production, and the packaging and testing technology should reach the international leading level. By 2030, the main IC supply chain should reach the international advanced level, with several enterprises at the world's top tier and achieving leapfrog development.
2015/5	The State Council	Made in China 2025	Efforts should be made to improve IC design technology, constantly enrich core intellectual property (IP) and design tools, achieve breakthrough in core general-purpose chips related to national information/network security and the development of the electronic industry. Improve the adaptability of domestic designed chips to different downstream applications. Develop domestic capability on high-density packaging and three-dimensional (3D) micro-assembly technology, and enhance the independent development capability of packaging industry and testing. Form supply capacity of key manufacturing equipment.
2016/3	National People's Congress	The 13th Five-Year Plan for Economic and Social Development of the People's Republic of China	Vigorously promote innovation and industrialization in emerging frontier areas such as advanced semiconductors, robots, advanced manufacturing, intelligent systems, new-generation aviation equipment, space technology integrated service systems, intelligent transportation, precision medical treatment, efficient energy storage and distributed energy systems, intelligent materials, efficient energy conservation and environmental protection, virtual reality and interactive film, etc. Create a series of new growth points.
2017/4	Ministry of Science and Technology	"13th Five-Year" Development Plan of National High-tech Industrial Development Zone	Optimize the industry structure and promote breakthroughs and applications in key technologies of integrated circuits and special equipment.
2018/3	Ministry of Finance (MoF), State Administration of Taxation, National Development and Reform Commission (NDRC), Ministry of Industry and Information Technology (MIIT)	Notice of Taxation on Enterprise Income Tax Policies for Integrated Circuit Manufacturing Enterprises	4 types of companies/projects are eligible for 50% of income tax reduction: (1) IC companies/projects established after 1 January 2018, with 130nm or more advanced technology and an operating period of more than 10 years. (2) IC companies/projects established after 1 January 2018, with 65nm or more advanced technology or an investment amount of more than RMB15bn with an operating period of more than 15 years. (3) IC companies/projects with 0.25um or more advanced technology established before 31 December 2017 and not profitable or with an investment amount of more than RMB8bn, and with an operating period of more than 15 years. (4) IC companies/projects established before 31 December 2017 and not profitable, with 0.8um (including) or more advanced technology.
2020/8	The State Council	Policies for Promoting the High-quality Development of Integrated Circuit Industry and Software Industry in the New Era	In order to further optimize the environment of development of integrated circuit industry and software industry, deepen international industrial cooperation, and enhance industrial innovation capability and development quality, a series of policies on finance, investment and financing, research and development, import and export, talent, intellectual property rights, market application and international cooperation were announced.
2021/3	National People's Congress	The 14th Five-Year Plan for Economic and Social Development of the People's Republic of China	Launch a number of major forward-looking and strategic national science and technology projects with focus on the fields of artificial intelligence, quantum information, integrated circuits, life and health, brain science, biological breeding, aerospace science and technology, deep earth and deep sea. Foster advanced manufacturing clusters and promote innovative development of integrated circuits, aerospace, ship and marine engineering equipment, robots, advanced rail transit equipment, advanced power equipment, construction machinery, high-end CNC machine tools, medicine and medical equipment.
2021/12	Central Cyberspace Affairs Commission	The 14th Five-Year Plan for National Informatization	Accelerate efforts to tackle key technologies for integrated circuits. Promote innovation in computing and memory chips, accelerate the research and development of key technology such as IC design tools, key equipment and high-purity targets, and promote breakthroughs in special processes such as insulated gate bipolar transistors (IGBT) and micro-electromechanical systems (MEMS).

Source: Public data, BOCOM Int'l

Figure 23: (Cont'd)China semiconductor related policies

Time	Issuing authority	Policy	Content
2022/1	**The State Council**	**The Plan for Development of the Digital Economy during the "14th Five-Year Plan" Period**	**Aim at strategic and forward-looking areas such as sensors, quantum information, network communication, integrated circuits, key software, big data, artificial intelligence, block chains and new materials. Efforts should be made to improve the supply of basic software and hardware, core electronic components, key basic materials and production equipment. Strengthen the self-sufficiency of key products.**
2022/3	The State Council	2022 Government Work Report	Promote the development of digital economy. Strengthen the overall layout of digital China construction. Build a digital information infrastructure, and gradually build a national integrated big data center system. Promote large-scale application of 5G, promote digital transformation of industries, and develop smart cities and digital villages. Accelerate the development of the industrial internet, foster and strengthen digital industries such as integrated circuits and artificial intelligence, and enhance the technological innovation and supply capacity of key software and hardware. Improve the governance of digital economy, cultivate the market of data elements, release the potential of data elements, improve the application ability, better enable economic development and enrich people's lives.
2022/6	MIIF and five other ministries	Industrial Energy Efficiency Improvement Action Plan	Support manufacturing enterprises to strengthen green revolution and improve the energy efficiency of information processing equipment such as network equipment. Promote the application of low-power consumption chips and other products and technologies in mobile communication networks, and promote the green transformation of power supply, air conditioning and other supporting facilities.
2023/8	MIIT, MoF	Action Plan for Steady Growth of Electronic Information Manufacturing Industry from 2023 to 2024	Promote the modernization level of industrial chain. Provide supports in focused areas such as integrated circuits, new displays, servers, photovoltaics and other fields. Improve the competitiveness of relatively weak links of the supply chain. Extend the lead of the strong parts of the supply chain. Upgrade the chain of the traditional industry. Build the supply chain of the emerging industry. Encourage, innovation and development of the supply chain, and comprehensively enhance the robustness of the supply chain.
2023/11	State Taxation Administration, MoF	Notice of the Ministry of Finance and State Taxation Administration on the Policy of Value-added Tax Deduction for Integrated Circuit Enterprises	From 1 January 2023 to 31 December 2027, IC design, production, sealing and testing, equipment and materials enterprises are eligible to deduct the output VAT payable according to the current deductible input VAT plus 15%.
2024/7	The Political Bureau of the Central Committee	Resolution of CPC Central Committee on Further Deepening Reform Comprehensively to Advance Chinese Modernization	Accelerate the construction of institutional mechanisms of promoting the development of digital economy, and improve the policy system of promoting digital industrialization and industrial digitalization. Efforts should be made to build an independent and controllable supply chain, and to improve and strengthen the development system and mechanism of key industrial chains such as integrated circuits, industrial mother machines, medical equipment, instrumentation, basic software, industrial software and advanced materials.

Source: Public data, BOCOM Int'l

National IC Industry Investment Fund to help domestic semiconductor industry compete globally

Among different forms of government direct funding support, the National IC Industry Investment Fund (also known as the Big Fund) provide the most amount of fiscal support to different parts of the supply chain in a comprehensive way.

Phase I of the Big Fund was established in September 2014 with a registered capital of RMB99bn, mainly invested in semi foundry, IC design, OSAT, and materials. Phase II was established in September 2019, with a registered capital of RMB204bn. Investment in equipment and materials increased significantly, and the scope of investment was more extensive than that of Phase I. Phase III was established in May 2024 with a registered capital of RMB344bn, larger than Phase I and Phase II combined. Six big SOE banks are among the investors of this phase. We expect Phase III of the Big Fund to invest in areas with low localization rate, such as CPU/GPU design, advanced process, and advanced memory.

Figure 24: National Integrated Circuit Industry Investment Fund (Big Fund)

Big Fund	Established in	Registered capital	Investment period	Key investment areas
Big Fund I	2014/9/26	RMB99bn	5-year investment period + 5-year payback period	Semi foundry accounted for 67%, including SMIC (981 HK) and HH Grace (1347 HK). IC design accounted for 17%, including Anlogic (688107 CH), Bdstar (002151 CH), and Gokemicro (300672 CH). OSAT accounted for 10%, including TFME (002156 CH), and JCET Group (600584 CH). Semi materials accounted for 6%, including ANJI Technology (688019 CH), NSIG (688126 CH), and Yoke Technology (002409 CH).
Big Fund II	2019/10/22	RMB204bn	5-year investment period + 5-year payback period	Investment in equipment and materials increased significantly, including NAURA (002371 CH) and AMEC (688012 CH). Compared with the Big Fund I, the investment scope was broader. EDA field included Semitronix (301095 CH) and Gcoreinc (688728 CH); the IC design field included Smarter Micro (688512 CH), and OSAT included HT Tech (002185 CH) and TFME (002156 CH).
Big Fund III	2024/5/24	RMB344bn	10-year investment period + 5-year payback period	We think the fund may invest in areas with low levels of domestic substitution, such as CPU/GPU design companies, advanced processing, and advanced memory.

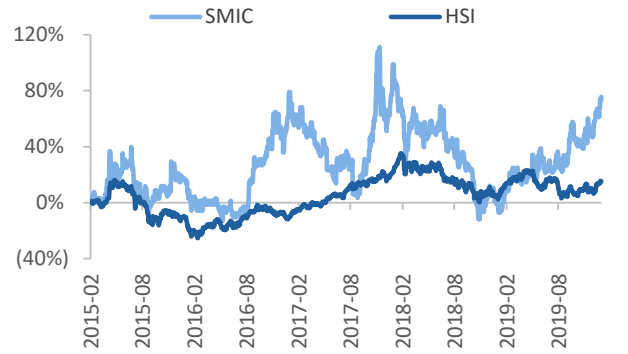
Source: Public data, BOCOM Int'l

Big Fund could be a catalyst of domestic semi stocks in short to medium term

While the benefits to IC design companies' sales and R&D progress from various government policies and Big Fund could be long term or sometimes even subtle, we believe the Big Fund could be a major catalyst for domestic semi stocks in the short to medium term.

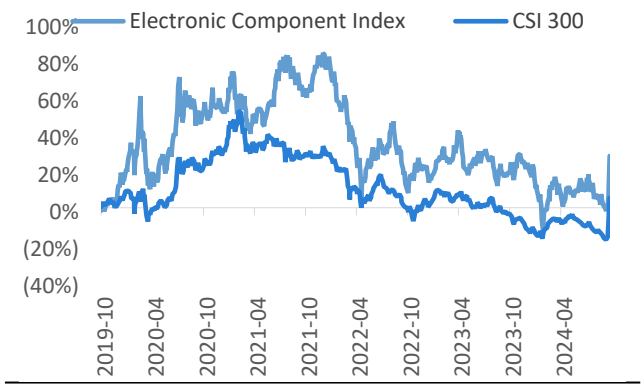
Historically, stocks reacted positively after the foundation of the two previous phases of Big Fund. After Phase I of Big Fund started its investment process in February 2015, stock price for SMIC (981 HK) outperformed benchmark Hang Seng Index by 25/5/60 ppts in a 12/18/24-month time span. We use SMIC as a proxy since there was a limited number of semiconductor-focused ETFs back in 2014/15 and the focus of Phase 1 of Big Fund was largely on semiconductor foundries.

Figure 25: SMIC stock price outperformed index after Big Fund I



Source: Wind, BOCOM Int'l

Figure 26: Electronic Components Index outperformed broader market after Big Fund II



Source: Wind, BOCOM Int'l

After the announcement of Phase II of Big Fund in October 2019, SW Electronics Components Index (801080 CH) outperformed benchmark CSI 300 by 26/16/35 ppts in a 12/18/24-month time span. The SW Electronics Components Index consists of a wide range of electronics stocks including IC design companies, semi foundries, semi cap equipment and OSAT companies.

We think investors are more enthusiastic on the outlook of the electronics related stocks following the announcement of Big Fund, on the expectation that (1) direct funding support could strengthen the R&D capability of domestic semiconductor companies and thus improve their global competitiveness; (2) abundant funding from Big Fund could help downstream players, especially foundries, to accelerate equipment procurement and thus benefit upstream vendors; (3) Big Fund could also invest in the secondary market and consequently improve the liquidity of the semiconductor stocks. Previously, Big Fund used to directly invest in the secondary market and consequently improved the liquidity of the semiconductor stocks. The visibility of whether Big Fund III will be investing in the secondary market is low.

Although the means and the detailed investment targets of Phase III of Big Fund are still unknown to the public, we believe IC design companies could be among the targets of funding support. We also believe investor enthusiasm towards semiconductor stocks could be repeated in the Phase III of Big Fund.

Risk Factors

Risks of investing in China domestic IC design companies include:

(1) Weaker-than-expected demand from downstream applications, including smartphone, automobile, consumer electronics, telecommunications equipment, PC, servers and industrial equipment;

(2) Slower-than-expected R&D progress resulting in a slower ramp up in key products;

(3) Domestic or foreign customers changing suppliers, resulting in reduced orders;

(4) Higher-than-expected R&D expense and/or CAPEX of new product development resulting in lower-than-expected margins;

(5) Supply chain localization progress slower than expected as domestic product could miss expectation of product qualification;

(6) Changes in global situations leading to a higher-than-expected cost of production or lower-than-expected end-product sales.

Appendix

Summary of semiconductor products

Semiconductor products can be divided into discrete device and integrated circuit (IC). Discrete devices are single semiconductors like diodes or transistors, while a typical IC product involves a collection of discrete devices. One way to categorize IC is based on the nature of signal the IC processes:

Analog IC refers to ICs which process, partially or entirely, analog (continuous) signals. Among analog signals, **Radio Frequency (RF)** signal typically involves continuous wave. As modulated wireless signals are normally in the form of RF signal, many analog ICs are used in mobile handsets. Maxscend is a leading domestic RF IC design company. **CMOS Image Sensor (CIS)** involves converting physical world (continuous) image to digital format signal. Willsemi is a leading domestic CIS design company. Another important category of ICs is in the space of **Power IC.**

Digital IC spans categories of logic IC, MCU (Micro Control Unit) & MPU (Micro Processor Unit) and memory IC. **Memory ICs** typically store data and do not involve logical operations. Depending on the specific applications, memory can be further divided into **Volatile Memory** (VM, ICs that requires power to maintain the stored information) and **Non-Volatile Memory** (NVM). **Logic ICs** typically refer to ICs that perform logical (normally compute) operations. As one of the most sophisticated parts of the IC sector, logic IC spans a wide range of data processing/computer circuitry from graphic processing unit (GPU) to field programmable logic array (FPGA). **MPU and MPC** are IC units with less electronics content used in applications such as industrial and auto industries.

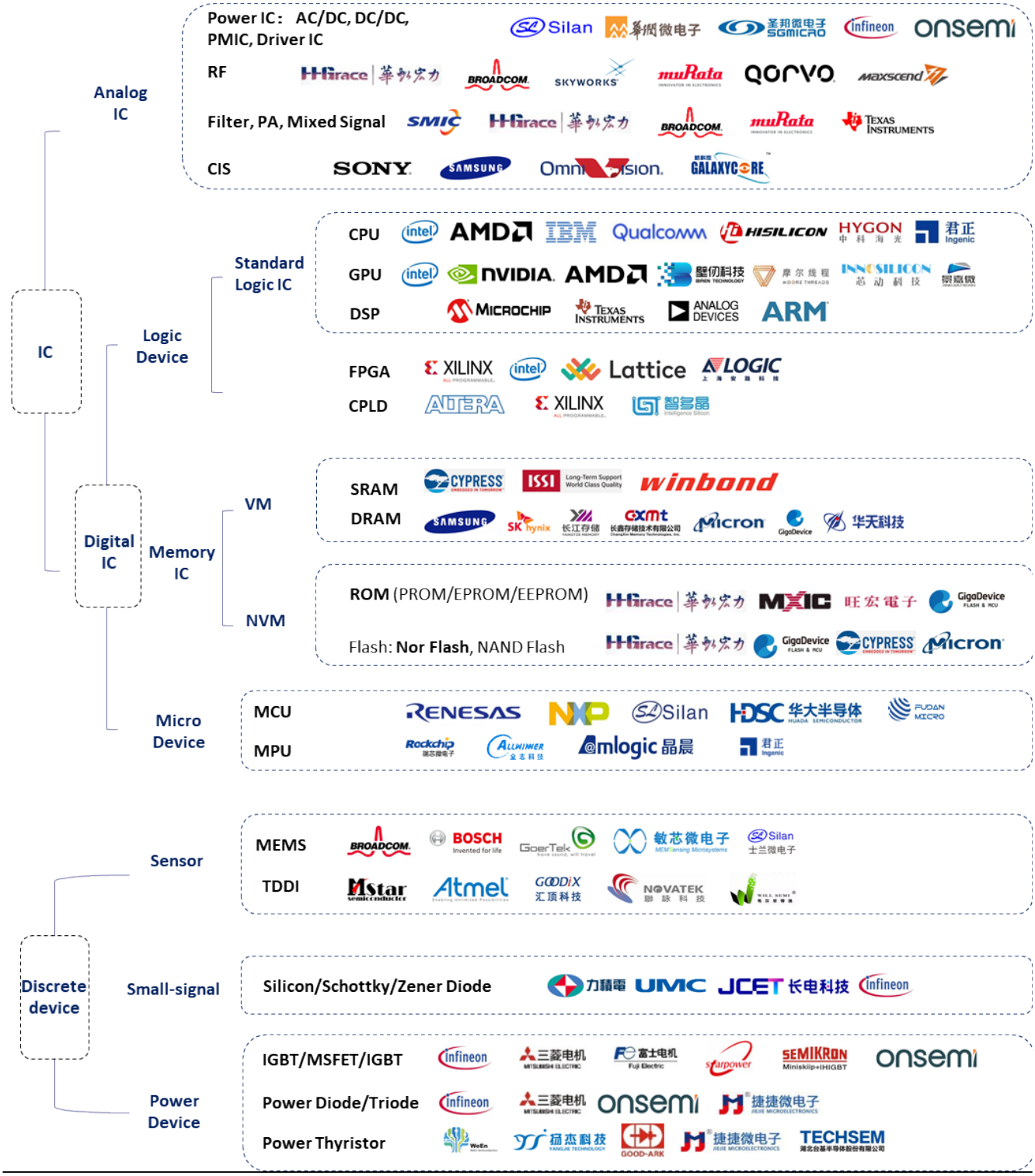
Discrete device refers to independent micro-electronics components such as diode, capacitor, inductor and resistor that are used in ICs as well as power electronics components such as IGBT. Sensors, sometimes in the form of micro-electromechanical system (MEMS) can also be considered as discrete devices.

Semiconductor market size and downstream applications

Global semiconductor industry, mainly driven by technological innovation, could increase at 8% CAGR from 2022 (US$600bn) to 2032 (US$1308bn) in total sales, higher than the growth rate of global nominal GDP, according to our estimation. We estimate that in 2023, global semiconductor industry recorded US$620bn in total revenue, with 32% (~US$200bn) from logic IC. Memory accounted for US$160bn in 2023 or 26%, followed by discrete devices, MPU&MCU and analog IC at 16%, 13%, 13%, respectively, according to our estimation.

Given the strong demand of AI infrastructure and acceleration processors, we estimate that global logic IC market will outgrow the broader semiconductor market at 9.8% CAGR from US$190bn in 2022 to US$485bn in 2032.

Figure 27: Summary of semiconductor products

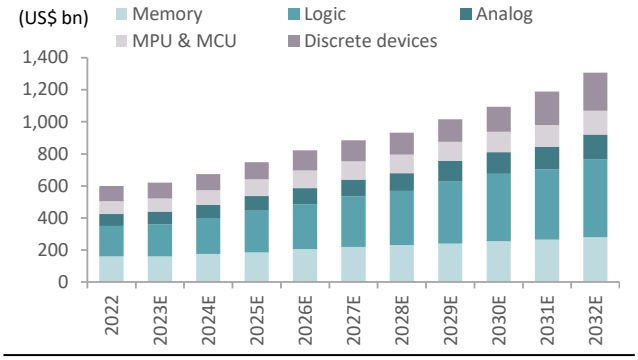


Source: Public data, BOCOM Int'l

For downstream applications, according to Gartner, about 23% of semiconductor revenue came from smartphone in 2022. Server/PC together made up 26%, followed by industrial, consumer electronics, auto and communication infrastructure at 11%, 11%, 10% and 8% respectively. Because of long supply chain and the inventory relationship between semiconductor vendors and the downstream players, supply and demand for the semiconductor industry follow some form of cycle amid the advancement of technology, both in semiconductor manufacturing and design technology. Downstream applications such as generative AI and new generation of communication standard (such as 5G) could also be factors that change the demand and supply dynamics of the industry.

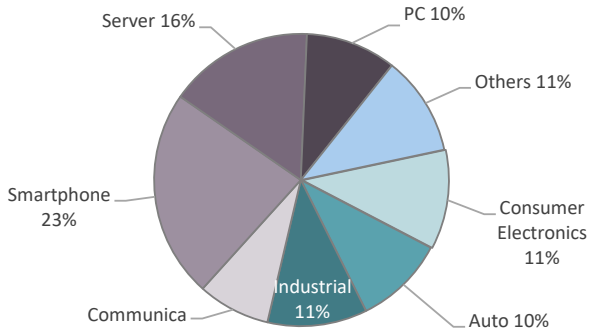
Although the demand cycles from different applications might not be completely in sync, we see that in times such as 2021 and 2022, the overall manufacturing capability of global semiconductor industry was in shortage, which led to a general price appreciation in various semiconductor products. The industry turned to oversupply in most categories since 2H22. As of 3Q24, demand for smartphone related semiconductor has been recovering, with downstream inventory level showing stabilization. Due to strong demand of supporting data center infrastructure for generative AI applications, server/PC supply has been tight since 2H23. On the other hand, downstream demand for communication infrastructure, auto and industrial-related semiconductor products remain soft and the inventory level for consumer electronics is still volatile.

Figure 28: Market size of different semi categories



Source: Market.us, BOCOM Int'l

Figure 29: Downstream application split of semi industry (2022)



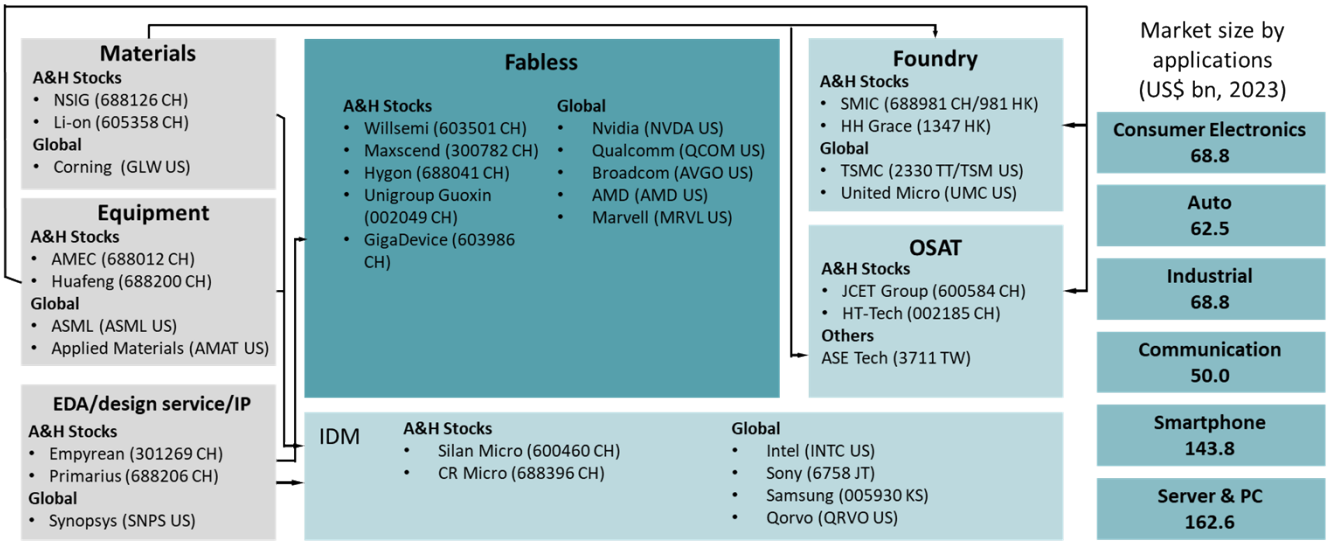
Source: Gartner, BOCOM Int'l

Semiconductor supply chain

Among various players of semiconductor supply chain, the role of IC design company (fabless companies) is paramount. An IC design company sits in the heart of supply chain in the sense that it leads the entire product R&D cycle. Before an IC product is introduced to downstream applications/customers, typically IC design companies initiate (sometimes in collaboration with downstream application vendors) the features, function and specification. IC design companies are responsible for understanding the demand (including the technical aspects and commercial value) for downstream end products and develop the products according to downstream needs.

IC design companies negotiate the terms, schedule and quantity of demand with the foundry before outsourcing the manufacturing to the foundry, while the foundry is responsible for allocating resources to procure wafer fabrication equipment (semi-cap equipment) and semiconductor materials for the manufacturing process. The foundry could manage the assembly and testing process internally or pass the work to OSAT (Outsourced Assembly and Testing) players.

Figure 30: Semiconductor supply chain



Source: BOCOM Int'l

Figure 31: BOCOM Int'l technology sector coverage

Stock code	Company name	Rating	CP (local ccy)	TP (local ccy)	Upside	Last TP/rating publication date	Sub-sector
AMD US	AMD Inc.	Buy	159.75	200.00	25.2%	3 Jun 2024	IC designer
300782 CH	Maxscend	Buy	92.89	107.00	15.2%	7 Oct 2024	IC designer
603501 CH	Will Semiconductor	Buy	107.20	133.00	24.1%	7 Oct 2024	IC designer

Source: FactSet, BOCOM Int'l estimates, as of 3 Oct 2024

Company Analysis

Technology

Last Close	Target Price	Upside
RMB 107.20	RMB 133.00	+24.1%

7 October 2024

Will Semiconductor (603501 CH)

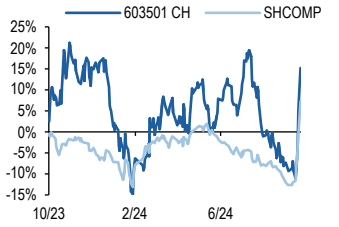
CIS leader to thrive amid supply chain localization; initiate with Buy

- **We initiate coverage on Will Semiconductor (Willsemi) with a Buy rating.** We like the company as the domestic leader of CMOS image sensor (CIS) subsector ranking No.3 in global market share after Sony and Samsung. As the largest downstream application of CIS, smartphone market is expected to recover after two years of decline. We expect domestic smartphone OEMs to gain market share, which could further benefit Willsemi as the CIS supplier for Xiaomi and Huawei. We also see Willsemi narrowing the technological gap to the global incumbents. Premiumization trend of CIS amid smartphone upcycle should also drive ASP. We predict Willsemi's market share in smartphone CIS to grow from 16.5% in 2023 to 20% in 2026.
- **We believe electrification and vehicle intelligence upgrade are the major drivers for auto CIS demand.** Our check shows that new EV models are equipped with much more CISs than ICE vehicles. Number of CIS used per vehicle is consistently robust across tiers of vehicles. According to Frost & Sullivan, global auto CIS market size is expected to grow from US$1.91bn in 2022 to US$4.86bn in 2027 at 20.6% CAGR. We study Willsemi's auto CIS product portfolio and we think the company could capture the market opportunities given a majority of EV OEMs are domestic.
- **In the long term, we see new growth driver in medical and AR/VR CIS market,** while surveillance CIS market could recover in 2025. The company's touch and display product has passed qualification of a major domestic LCD vendor. We also expect analog business to further penetrate into the domestic EV supply chain.
- **TP of RMB133 implies 35x 2025E P/E**. We expect Willsemi to reach RMB26.4bn and RMB30.5bn in revenue in 2024E/25E. We estimate EPS to be RMB2.91/3.80/4.16 in 2024E/25E/26E respectively, implying a 19.6% EPS CAGR for 2024-26. Our 2024E/25E EPS estimates are higher than Visible Alpha consensus. The company is now trading at 31.2x (NTM), much lower than domestic IC design sector median of 46.4x and historic average at 43.2x NTM P/E. As one of the leaders in global CIS market and the most prominent domestic IC design company, we think the current valuation level is attractive.

Stock Rating

BUY

1-year stock performance



Source: FactSet

Stock data

52w high (RMB)	112.76
52w low (RMB)	79.22
Market cap (RMB m)	128,400.94
Avg daily vol (m)	36.55
YTD change (%)	0.46
200d MA (RMB)	97.02

Source: FactSet

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Financial highlights

Y/E 31 Dec	2022	2023	2024E	2025E	2026E
Revenue (RMB m)	20,078	21,021	26,381	30,457	33,019
YoY growth (%)	-16.7	4.7	25.5	15.4	8.4
Net profit (RMB m)	990	556	3,531	4,613	5,049
EPS (RMB)	0.84	0.47	2.91	3.80	4.16
YoY growth (%)	-77.9	-44.2	521.4	30.6	9.4
P/E (x)	127.8	229.2	36.9	28.2	25.8
BVPS (RMB)	15.26	18.05	20.06	23.31	26.43
P/B (x)	7.02	5.94	5.34	4.60	4.06

Source: Company data, BOCOM Int'l estimates

Financial Forecast

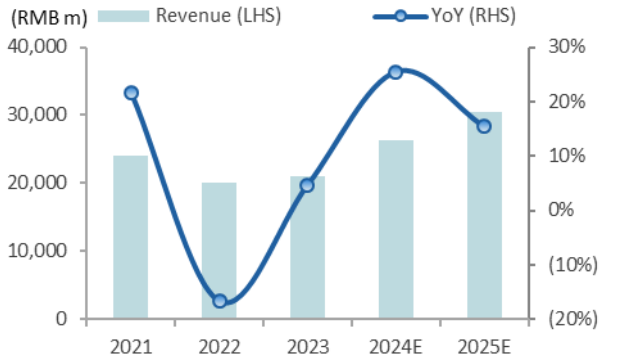
Willsemi's revenue grew 35%/36% YoY in 2H23/1H24, mainly driven by (1) downstream (primarily smartphone market) customer demand recovery since 2H23; (2) Willsemi continuing to improve its position in value chain and obtain larger share of high-end smartphone market, amid the supply chain localization theme; (3) penetration of EV and autonomous driving continuing to increase, which benefits image sensor vendors including Willsemi as demand surges. We believe that the downstream demand could continue to recover and Willsemi could further benefit from the supply chain domestic substitution trend. We estimate Willsemi's 2024 and 2025 revenue to reach RMB26.4bn and RMB30.5bn, respectively, corresponding to a growth rate of 26% and 15%.

With respect to different revenue segments, Willsemi's **image sensor** revenue grew by 50% YoY in 1H24, reaching RMB9.3bn, accounting for 77% of the total revenue. Within the image sensor segment, smartphones, auto, surveillance, IoT/emerging market, medical, and PC accounted for 52%, 31%, 8%, 4%, 3%, and 2% respectively. As the major contributor of growth, smartphone and auto image sensor revenue grew by 79% and 53% YoY in 1H24. We believe revenue for these two segments could continue to grow/recover in the next 2 years. Affected by the weak demand of surveillance market, we expect surveillance image sensor revenue to decline in 2024. Benefiting from emerging markets such as AR/VR and medical endoscope, we are optimistic about Willsemi's IoT/emerging market and medical image sensor growth potential in the long term. In summary, we expect Willsemi's 2024E/25E image sensor revenue to reach RMB20.6bn/24.3bn, respectively, with YoY growth at 33% and 18%.

Willsemi's **touch and display** revenue in 1H24 was RMB472m, down 29% YoY, accounting for 4% of the total revenue, mainly due to ASP pressure on display-related products. Despite the cyclical impact of display market, we believe that Willsemi's expansion and innovation in smartphone OLED DDIC, mid-size TED and auto TDDI could allow the revenue decline to moderate in 2024 and regrow at 17% YoY to reach RMB1156m in 2025. Willsemi's **analog** revenue grew 25% YoY in 1H24, reaching RMB634m, accounting for 5% of the total revenue, mainly driven by progress of downstream inventory re-stocking and market share gains. With its auto analog product portfolio continuing to expand to CAN/LIN, SerDes, PMIC, SBC, etc., we estimate analog business revenue to reach RMB1443m and RMB1674m in 2024 and 2025, respectively, with YoY growth of 25% and 16%.

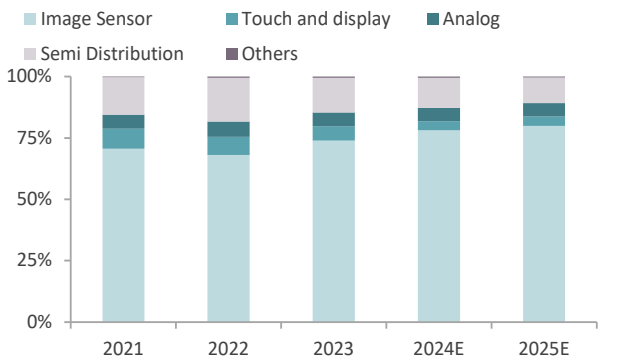
Willsemi's gross margin fell 13.4ppts YoY and 5.5ppts sequentially to 20.9% in 1H23, mainly due to pressure on ASP with supply chain de-stocking. We see Willsemi's inventory dropped to RMB6.76bn at the end of 2Q24, down 31% YoY, and the gross margin recovered to 30.2% in 2Q24, up 12.9ppts YoY and 2.4ppts sequentially, mainly driven by downstream inventory re-stocking. We also think ASP could rebound and GPM might recover to 2022 level. Driven by Willsemi's expansion to high-end smartphones and EV market, supply chain inventory re-stocking and product premiumization, we estimate a gross margin recovery going forward. We expect GPM to achieve 30.6% in 2024 and 32.7% in 2025. Note that both GPM numbers are lower than cycle peak GPM at 34.5% in 2021, which we do not have visibility for the company to re-achieve in this upcycle yet.

Figure 32: Willsemi revenue



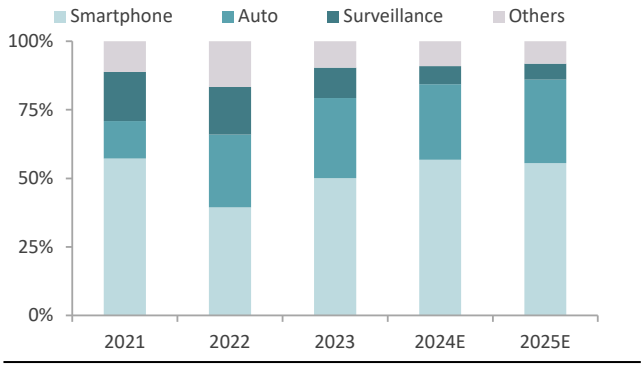
Source: Willsemi, BOCOM Int'l estimates

Figure 33: Willsemi revenue split



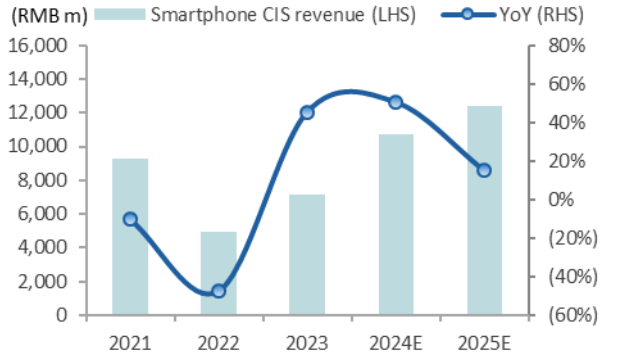
Source: Willsemi, BOCOM Int'l estimates

Figure 34: Willsemi image sensor rev. breakdown



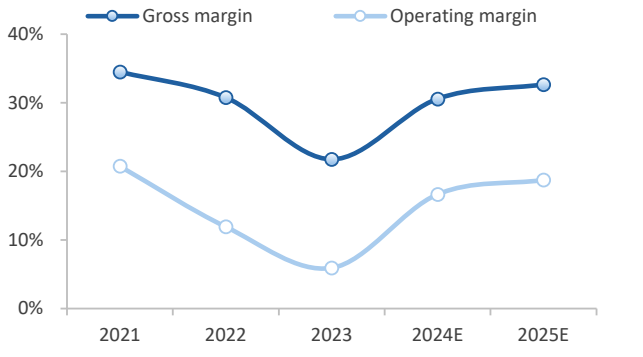
Source: Willsemi, BOCOM Int'l estimates

Figure 35: Willsemi smartphone CIS revenue



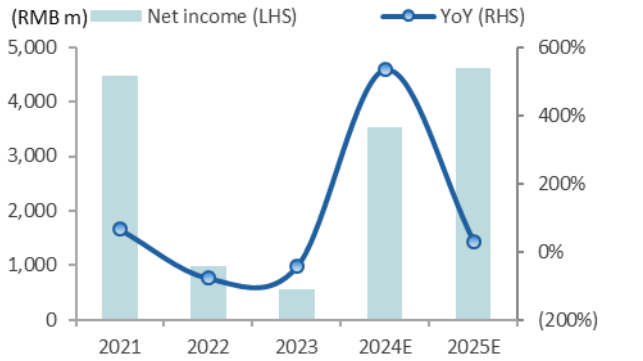
Source: Willsemi, BOCOM Int'l estimates

Figure 36: Willsemi gross / operating margin



Source: Willsemi, BOCOM Int'l estimates

Figure 37: Willsemi net income



Source: Willsemi, BOCOM Int'l estimates

Figure 38: Key assumptions of Willsemi

RMB m	2022	2023	2024E	2025E	2026E	1Q24	2Q24	3Q24E	4Q24E
Revenue	20,078	21,021	26,381	30,457	33,019	5,644	6,448	6,991	7,299
Gross profit	6,175	4,574	8,063	9,945	10,848	1,574	1,950	2,221	2,319
Operating expense	(3,777)	(3,325)	(3,667)	(4,233)	(4,590)	(923)	(937)	(884)	(923)
R&D	(2,496)	(2,234)	(2,322)	(2,711)	(2,906)	(623)	(633)	(522)	(545)
Sales/marketing/advertising	(516)	(467)	(554)	(609)	(693)	(127)	(137)	(142)	(148)
General and administrative	(765)	(623)	(791)	(914)	(991)	(173)	(168)	(221)	(230)
Operating income	2,398	1,250	4,396	5,712	6,258	651	1,012	1,337	1,396
Net income	990	556	3,531	4,613	5,049	558	809	1,062	1,108
Basic EPS (RMB)	0.84	0.47	2.91	3.80	4.16	0.46	0.67	0.87	0.91
YoY									
Revenue	*(17%)*	*5%*	*26%*	*15%*	*8%*	*30%*	*43%*	*12%*	*23%*
Gross profit	*(26%)*	*(26%)*	*76%*	*23%*	*9%*	*47%*	*149%*	*64%*	*70%*
Operating income	*(52%)*	*(48%)*	*252%*	*30%*	*10%*	*76%*	*2396%*	*185%*	*277%*
Net income	*(78%)*	*(44%)*	*535%*	*31%*	*9%*	*181%*	*NM*	*393%*	*492%*
Margin									
Gross margin	30.8%	21.8%	30.6%	32.7%	32.9%	27.9%	30.2%	31.8%	31.8%
Operating margin	11.9%	5.9%	16.7%	18.8%	19.0%	11.5%	15.7%	19.1%	19.1%
Net margin	4.9%	2.6%	13.4%	15.1%	15.3%	9.9%	12.6%	15.2%	15.2%
Expense ratio (% of revenue)									
OPEX	(18.8%)	(15.8%)	(13.9%)	(13.9%)	(13.9%)	(16.4%)	(14.5%)	(12.6%)	(12.6%)
R&D	(12.4%)	(10.6%)	(8.8%)	(8.9%)	(8.8%)	(11.0%)	(9.8%)	(7.5%)	(7.5%)
Sales/marketing/advertising	(2.6%)	(2.2%)	(2.1%)	(2.0%)	(2.1%)	(2.2%)	(2.1%)	(2.0%)	(2.0%)
General and administrative	(3.8%)	(3.0%)	(3.0%)	(3.0%)	(3.0%)	(3.1%)	(2.6%)	(3.2%)	(3.2%)
Revenue by segments	**2022**	**2023**	**2024E**	**2025E**	**2026E**				
Image sensor	13,675	15,536	20,604	24,344	26,655				
Smartphone	5,397	7,779	11,701	13,528	14,487				
Auto	3,633	4,547	5,670	7,414	8,476				
Surveillance	2,371	1,722	1,379	1,427	1,490				
Others image sensor	2,274	1,488	1,855	1,976	2,203				
Touch and display	1,471	1,250	988	1,156	1,271				
Analog	1,262	1,154	1,443	1,674	1,841				
Semi distribution	3,565	2,970	3,237	3,173	3,141				
Others	106	110	109	110	110				
Total	**20,078**	**21,021**	**26,381**	**30,457**	**33,019**				

Source: Willsemi, BOCOM Int'l estimates

Comparing to the consensus numbers from Visible Alpha (VA), our revenue estimation is slightly lower due to our lower revenue estimation in the company's semiconductor distribution business. Our estimation of image sensor, the company's major revenue contributor, is higher than VA consensus. Since image sensor business typically has a higher margin than the distribution business, our EPS estimation in 2024E/25E of RMB2.91/3.80 are higher than VA consensus at RMB2.67/3.59.

Figure 39: Financials estimates of Willsemi (BOCOM vs Visible Alpha)

RMB m	2024E	2025E	2026E	3Q24E	4Q24E	1Q25E	2Q25E	3Q25E	4Q25E
Revenue	26,381	30,457	33,019	6,991	7,299	6,804	7,266	8,069	8,318
VA	26,578	30,929	34,922	7,176	7,302	6,681	7,456	8,340	8,492
Diff.	*(1%)*	*(2%)*	*(5%)*	*(3%)*	*(0%)*	*2%*	*(3%)*	*(3%)*	*(2%)*
Gross profit	8,063	9,945	10,848	2,221	2,319	2,222	2,372	2,635	2,716
VA	7,834	9,532	10,922	2,193	2,262	2,014	2,298	2,650	2,834
Diff.	*3%*	*4%*	*(1%)*	*1%*	*3%*	*10%*	*3%*	*(1%)*	*(4%)*
Operating income	4,396	5,712	6,258	1,337	1,396	1,276	1,363	1,513	1,560
VA	3,842	5,094	6,081	1,130	1,164	1,029	1,240	1,486	1,608
Diff.	*14%*	*12%*	*3%*	*18%*	*20%*	*24%*	*10%*	*2%*	*(3%)*
Net income	3,531	4,613	5,049	1,062	1,108	1,030	1,100	1,222	1,260
VA	3,248	4,394	5,293	963	985	867	1,049	1,268	1,392
Diff.	*9%*	*5%*	*(5%)*	*10%*	*13%*	*19%*	*5%*	*(4%)*	*(10%)*
Basic EPS (RMB)	2.91	3.80	4.16	0.87	0.91	0.85	0.91	1.01	1.04
VA	2.67	3.59	4.30	0.79	0.78	0.74	0.87	1.05	1.07
Diff.	*9%*	*6%*	*(3%)*	*11%*	*17%*	*15%*	*4%*	*(5%)*	*(3%)*

Source: Visible Alpha, BOCOM Int'l estimates

Valuation

Our target price of RMB133 implies 35x 2025E EPS of RMB3.80. Our EPS estimates are RMB2.91/3.80/4.16 for 2024E/25E/26E respectively, implying 19.6% CAGR between 2024 and 2026. Historically, the company trades at an average of 43.2x NTM P/E with a standard deviation of 15.5x. Its most immediate group of peers of domestic IC design sector are trading at a median of 46.4x 2025 P/E. We value Willsemi at 35x 2025E P/E multiple based on the following:

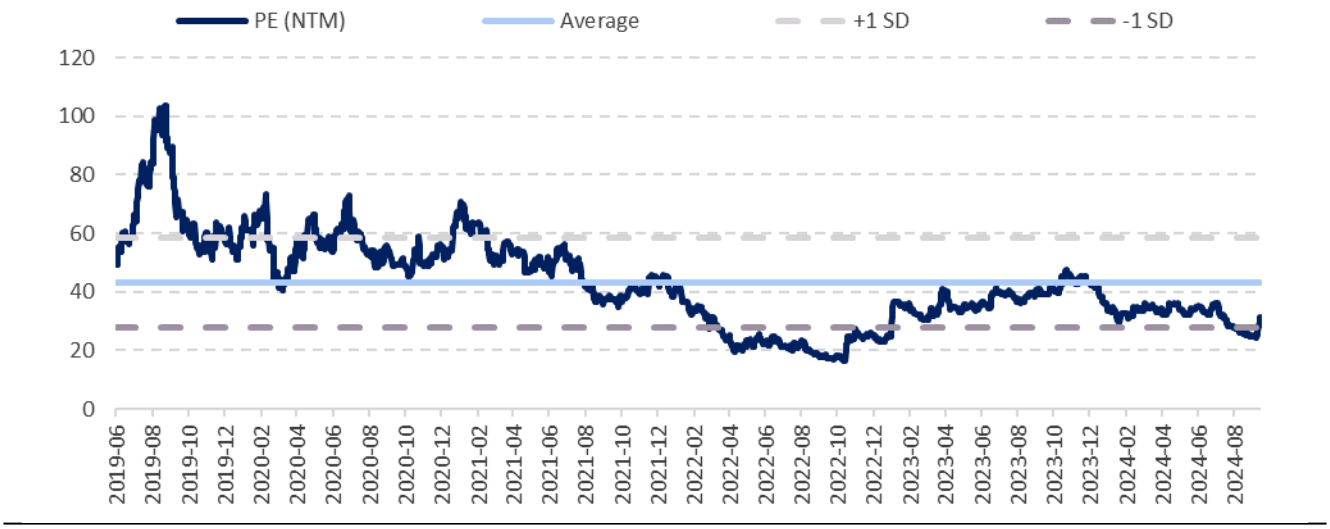
1) We think the company is one of the leaders in CIS in the world and one of the most prominent companies in the domestic Chinese IC design sector. Its No.3 market share ranking in its specific area of CIS is among the highest of domestic IC design companies in their respective areas of expertise. We thus think that the current NTM P/E multiple of 31.2x, a discount with respect to the group median, is appealing;

2) We like the competition landscape of global CIS industry. With a few industry leaders, including Samsung and Sony, we see limited possibility of price war and healthy competition among industry participants. As the relationship between CIS vendors and smartphone and auto OEM are typically built over a long period of time, we see a high barrier of entry in the CIS market. We think a 1.8x PEG (35x 2025 PE and 19.6% net profit CAGR from 2024 to 2026), higher than domestic IC design companies' median of 1.2x, not only reflects the favorable market condition for Willsemi as a CIS market leader, but also is consistent with investors' enthusiasm towards stocks that align with government policy direction. As one the largest domestic IC design companies, the growth rate of Willsemi could be relatively slower than its peers and thus we think Willsemi's multiple might not imminently converge to the group median at 46.4x 2025 P/E;

3) The relatively high historic average multiple is largely due to (1) the effect of high growth stage when the size of company was relatively small and (2) investors' hype on semiconductor stock in supply shortage period before 2021. We also see the company trading below 20x NTM P/E in a semi downcycle and demand shortage period in 2022. As one of the largest market cap and revenue size names in China's domestic IC design space, we see limited opportunity for company to be trading at 2019 level of over 55x NTM P/E unless the growth of the company further accelerates. We also think the semiconductor demand recovery and industry upcycle prevent the P/E to fall back to 2H22 levels;

4) We think upside catalysts for the stock includes: further penetration into key downstream auto or mobile OEM supply chain; Chinese OEM unable to purchase foreign image sensor products leading to import substitution; demand surge for new applications such as autonomous driving, AI on the edge or AR/VR devices.

Figure 40: Willsemi's P/E band (forward 12 months)



Source: Bloomberg, BOCOM Int'l

Figure 41: Valuation Comparison

Ticker	Name	Market cap (US$ mn)	Last price (LC)	Price ytd (%)	yoy growth of EPS (24-26E)	PE 2024E	PE 2025E	PEG 2025E	PB 2024E	PB 2025E
Domestic IC design										
603501 CH Equity	Willsemi	18,549	107.20	0%	20%	36.8	28.2	1.4	5.3	4.6
300782 CH Equity	Maxscend	7,074	92.89	(34%)	27%	58.4	46.9	1.7	4.6	4.1
688041 CH Equity	Hygon	34,203	103.28	46%	35%	136.6	99.8	2.8	11.8	10.6
603986 CH Equity	GigaDevice	8,384	88.37	(4%)	37%	52.6	35.3	1.0	3.6	3.4
300661 CH Equity	SGMICRO	6,387	95.00	7%	47%	97.9	62.6	1.3	10.6	9.3
600460 CH Equity	Silan	5,363	22.62	(1%)	75%	113.7	46.4	0.6	3.0	2.9
603290 CH Equity	Starpower	3,112	91.25	(29%)	18%	24.7	20.3	1.1	3.1	2.9
688052 CH Equity	Novosense	2,412	118.80	(29%)	N/A	N/A	195.1	N/A	2.8	2.7
688153 CH Equity	Vanchip	2,225	36.32	(45%)	33%	46.2	34.1	1.0	3.7	3.0
Median						55.5	46.4	1.2	3.7	3.4
Overseas IC design										
NVDA US Equity	Nvidia	2,978,923	121.44	145%	31%	42.0	29.4	0.9	30.8	16.2
AVGO US Equity	Broadcom	805,674	172.50	55%	22%	35.2	27.3	1.2	12.1	10.4
AMD US Equity	AMD	265,561	164.08	11%	47%	47.1	29.4	0.6	4.4	4.1
QCOM US Equity	Qualcomm	189,436	170.05	18%	10%	16.7	15.1	1.5	7.4	6.2
MRVL US Equity	Marvell	62,470	72.12	20%	52%	49.0	28.6	0.6	4.4	4.3
Median						42.0	28.6	0.9	7.4	6.2
Semi foundry										
2330 TT Equity	TSMC	783,780	957.00	61%	23%	23.1	18.1	0.8	5.9	4.8
981 HK Equity	SMIC	33,051	20.85	5%	30%	34.7	24.6	0.8	1.1	1.0
GFS US Equity	GlobleFoundries	22,359	40.25	(34%)	44%	30.7	22.1	0.5	1.9	1.7
1347 HK Equity	HH Grace	5,717	20.90	11%	65%	45.5	22.6	0.3	0.8	0.7
Median						32.7	22.3	0.6	1.5	1.4
Smartphone parts										
300433 CH Equity	Hnlens	14,519	20.45	55%	21%	26.2	20.4	1.0	2.1	2.0
002241 CH Equity	Geortek	11,037	22.67	8%	27%	29.5	22.3	0.8	2.3	2.2
300207 CH Equity	Sunwoda	5,826	21.96	49%	53%	25.3	19.7	0.4	1.7	1.5
2018 HK Equity	AAC	4,921	31.90	38%	(1%)	21.0	16.2	(13.8)	1.5	1.3
002456 CH Equity	Ofilm	4,692	9.95	14%	1%	57.5	36.4	63.2	7.9	7.5
300136 CH Equity	Sunway	3,198	23.20	(2%)	27%	30.5	23.2	0.8	2.9	2.6
Median						27.8	21.4	0.8	2.2	2.1
CMOS										
005930 KS Equity	Samsung	279,195	61,500.00	(22%)	22%	11.2	8.5	0.4	1.1	1.0
6758 JT Equity	Sony	121,159	2,777.50	4%	15%	18.3	16.8	1.1	2.3	2.0
000660 KS Equity	SK Hynix	96,661	174,600.00	23%	27%	7.0	4.5	0.2	1.7	1.3
603501 CH Equity	Willsemi	18,549	107.20	0%	20%	36.8	28.2	1.4	5.3	4.6
Median						14.8	12.7	0.8	2.0	1.7
RFFE										
300782 CH Equity	Maxscend	7,074	92.89	(34%)	27%	58.4	46.9	1.7	4.6	4.1
300661 CH Equity	SGMICRO	6,387	95.00	7%	47%	97.9	62.6	1.3	10.6	9.3
688153 CH Equity	Vanchip	2,225	36.32	(45%)	33%	46.2	34.1	1.0	3.7	3.0
688798 CH Equity	Awinic	1,921	57.94	(16%)	105%	66.1	35.8	0.3	3.5	3.2
688536 CH Equity	3peak	1,907	100.96	(31%)	42%	86.5	41.4	1.0	2.3	2.2
Median						66.1	41.4	1.0	3.7	3.2

Source: Bloomberg, BOCOM Int'l Last price as of 2024/9/30

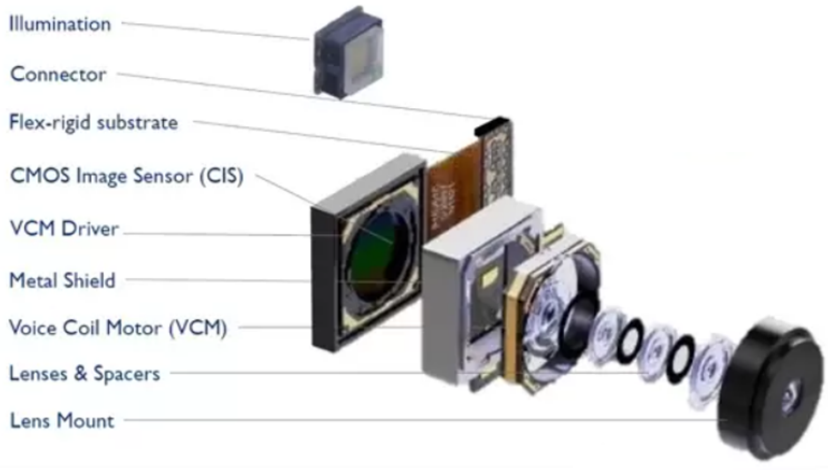
Progress in Technical Know-how and Narrowing the Gap with Foreign Competitors

We are optimistic about the prospect of Willsemi as the domestic leader in the CMOS image sensor (CIS) segment. According to our analysis, we believe the technology of Willsemi CIS products (under the name of OmniVision, 100% controlled by Willsemi) has made great progress in catching up with global incumbents, namely Sony and Samsung Electronics. Willsemi's CIS chips have been widely adopted by domestic mobile handset OEMs including Huawei and Xiaomi. As we discussed in the sector report, Chinese mobile handset OEMs account for around 75% of global production, and we see Willsemi continue to penetrate the domestic mobile handset supply chain. We also see trend of product premiumization going forward. We think CIS could be one of the first areas where domestic IC design companies can achieve supply chain independence. We predict that Willsemi's global market share of smartphone CIS to grow from 16.5% in 2023 to 20% in 2026. With mobile handset/smartphone market entering upcycle since 2H23, we think Willsemi is well positioned to benefit from the market opportunity of rising downstream mobile CIS demand. We predict the company's smartphone CIS revenue to grow from RMB7.16bn in 2023 to RMB13.08bn in 2026, at a 22.3% CAGR.

CIS evolves and gains importance in global tech supply chain

From mobile handset to personal computer (PC), the evolution of global consumer electronics almost always involves upgrade of camera. **CIS is a key component with the largest value in CMOS Camera Module (CCM) products.** Generally speaking, a CCM consists of three core parts: CIS, lens, and voice coil motor (VCM). According to Chyxx, CIS accounts for 52% of the BOM cost in CCM, with the remaining module assembly, lens, VCM and filter accounting for 20%, 19%, 6% and 3% respectively.

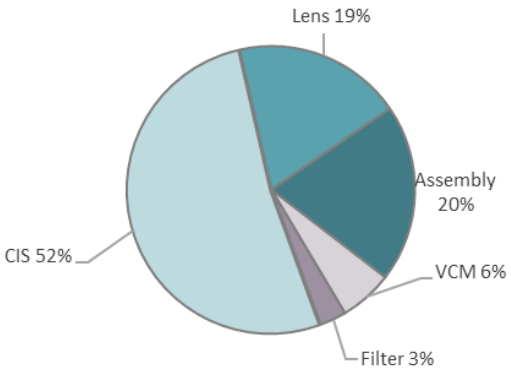
Figure 42: CIS is a critical part of CCM products



Source: Yole, BOCOM Int'l

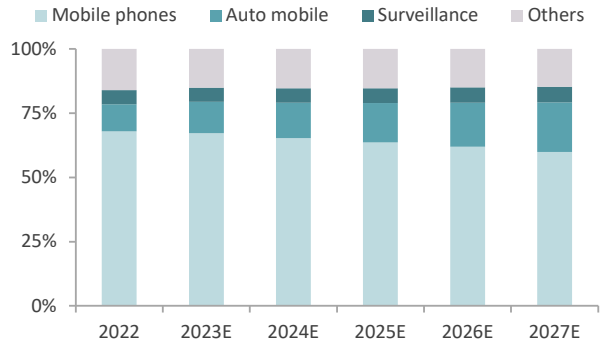
Mobile handset is the major application for CIS, while demand from the automobile sector is rising. According to Frost & Sullivan, mobile handsets, automobiles, and surveillance equipment are the three most important downstream applications of CIS, accounting for 68%, 11%, and 5% respectively in 2022. Going forward, demand from automobiles could rise as electrification and autonomous driving technology demand more CIS per vehicle, as we will discuss in detail in the next section.

Figure 43: BOM cost of camera (2020)



Source: Qianzhan, BOCOM Int'l

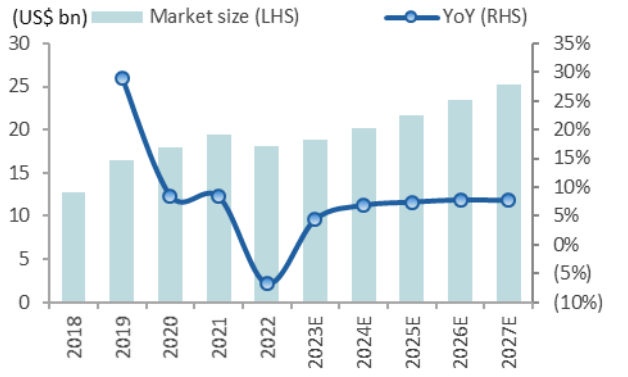
Figure 44: Global CIS by applications



Source: Frost & Sullivan, BOCOM Int'l E= Frost & Sullivan estimates

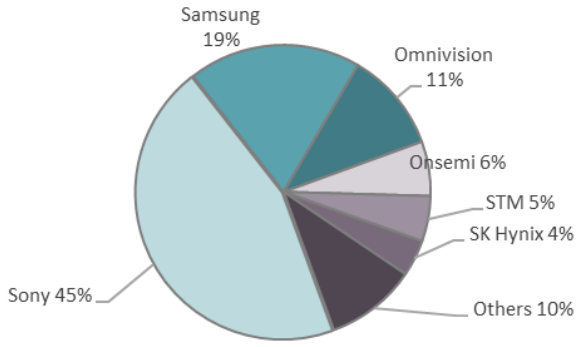
According to Frost & Sullivan, global CIS market size grew from US$12.8bn in 2018 to US$19.4bn in 2021 at a CAGR of 14.9%. CIS market shrank in 2022 to US$18.1bn amid global IC market downturn and mobile handset vendors' efforts to bring down the inventory levels. We think the CIS market has been recovering since 2023, yet the growth rate has moderated comparing to pre-2021 level. Looking ahead, Frost & Sullivan estimates **the market size of global CIS to maintain a YoY growth between 4% and 8% from 2023 to 2027.** Despite macro volatility, the market size is expected to reach US$25.2bn in 2027 on 7.5% CAGR from 2023 to 2027 driven by demand normalization and product premiumization largely from mobile handset applications.

Figure 45: Global CIS market size



Source: Frost & Sullivan, BOCOM Int'l E= Frost & Sullivan estimates

Figure 46: Global CIS market share (2023)



Source: Yole, BOCOM Int'l

In terms of competition landscape, **we think the market for CIS is relatively concentrated among large players**. According to Yole, in 2023, Sony, Samsung and OmniVision/Willsemi had market shares of 45%, 19%, and 11% respectively. Onsemi, STM and SK Hynix, although relatively small in market shares, all have products specialized for different applications such as automobile and machinery. As the incumbent of the CIS market, Sony is the main supplier of Apple's iPhone. Samsung's CIS products are mainly used by its own Galaxy smartphone models. We notice that, OmniVision/Willsemi is the only domestic player with material global market share. As discussed in the sector report, we think the relatively concentrated market structure avoids stiff competition and may mitigate or even prevent price competition among vendors. We believe Willsemi is well positioned in the competition given that the company's smartphone and EV OEM clients are predominantly domestic.

Willsemi CIS catching up in technology

We believe OmniVision/Willsemi now possesses comparable if not better CIS technologies with respect to the global incumbents, Sony and Samsung. We compare the product lineups among these three CIS vendors and we find that the technical aspects of OmniVision's products to be very similar to those from Sony and Samsung.

In general, there are three main parameters that determine the performance of an image sensor:

1) Sensor size (also known as Optical Format or OF): denoted as a fraction, which reads as "one inch video camera tube equivalent", is the measure of the diagonal of the image sensor. A larger OF indicates a more powerful sensor;

2) Resolution (pixel number): a higher value of resolution means the sensor can describe an image in a more granular way. 50MP means the sensor has 50m pixels;

3) Single pixel size: measures the dimension of one single pixel. Given a fixed sensor size, resolution and single pixel size are typically negatively correlated.

According to Willsemi, its most advanced products, including IMX989, OV50H, and OV50K40 have entered the main camera supplier list of Huawei and Xiaomi's latest mobile handset models. Willsemi's flagship series OV50 has evolved from the basic model of OV50E to a premium model of OV50H with a larger single pixel size and OF, aiming for high-end smartphone main camera market. In 1H24, Willsemi launched a more advanced OV50K40, which is company's first smartphone image sensor model using company's proprietary TheiaCel technology, allowing enhanced picture quality when the camera is moving with a fast speed.

When we compare the product specs of Sony (mainly IMX803 and IMX904) and OmniVision OV50 series, we see the two groups of products have similar technical sophistication (technically, for comparable technologies, resolution times (single pixel size)^2 should be proportional to (sensor size)^2). The fact that Sony's products are widely used in Apple also gives us the confidence to believe that OmniVision is competitive in CIS market for high-end smartphone.

Figure 47: CIS comparison: Sony vs OmniVision vs Samsung; OmniVision is catching up in technology

Brand	CIS	Sensor size	Pixel number	Single pixel size	Carried in	Camera type
Sony	IMX803	1/1.3"	48MP	1.22μm	iPhone 15 Pro Max	Main
	IMX633	1/2.55"	12MP	1.4μm	iPhone 15 Pro Max	Ultra-Wide
	IMX714	1/3.6"	12MP	1.0μm	iPhone 15 Pro Max	Telephoto
	IMX904	1/1.59"	48MP	1.0μm	iPhone 15 Plus	Main
	IMX772	1/3.6"	12MP	1.0μm	iPhone 15 Plus	Ultra-Wide
	IMX714	1/3.6"	12MP	1.0μm	iPhone 15 Plus	Telephoto
OmniVision	IMX989	1"	50MP	1.6μm	HUAWEI Pura 70 Ultra	Main
	OV50H	1/1.3"	50MP	1.2μm	HUAWEI Pura 70 Pro+	Main
	IMX888	1/1.43"	48MP	1.12μm	HUAWEI P60 Pro	Main
	IMX789	1/1.43"	48MP	1.12μm	HUAWEI P60	Main
	OV50K40	1/1.3"	50MP	1.2μm	Xiaomi 15 Pro	Main
	LYT-900	1/0.98"	50MP	1.6μm	Xiaomi 14 Ultra	Main
	LYT-808	1/1.43"	48MP	1.12μm	OPPO Find N3	Main
	OV50E	1/1.5"	50MP	1.0μm	HUAWEI nova 12 Ultra	Main
	OV64B	1/2"	64MP	0.7μm	OPPO Find N3	Telephoto
Samsung	HP2SX	1/1.3"	200MP	0.6μm	Galaxy S24 Ultra	Main
	HP2	1/1.3"	200MP	0.6μm	Galaxy S23 Ultra	Main
	HM3	1/1.33"	108MP	0.8μm	Galaxy S22/21 Ultra	Main
	HM1	1/1.33"	108MP	0.8μm	Galaxy S20 Ultra	Main

Source: Public data, BOCOM Int'l

As a context, we list the CIS specs of iPhone 14/15. An iPhone is typically equipped with more than 3 cameras, with the main camera having the bigger sensor and higher resolution. We see Apple made a major upgrade of the main camera for the basic model from iPhone 14 to 15. Ultra-wide and telephoto cameras are often of lower resolution and smaller sensor size for cost reason for iPhone. Huawei, Xiaomi and Samsung's models could use high resolution (48 or 50MP) cameras.

Figure 48: Specs of CIS in iPhone

	iPhone 15 Pro Max / iPhone 15 Pro			——iPhone 15 Plus / iPhone 15——		
	Main	**Ultra-Wide**	**Telephoto**	**Main**	**Ultra-Wide**	**Telephoto**
CIS	**IMX803**	**IMX633**	**IMX714**	**IMX904**	**IMX772**	**IMX714**
Color filter array	QBC	Bayer	Bayer	QBC	Bayer	Bayer
Sensor size	**1/1.3"**	**1/2.55"**	**1/3.6"**	**1/1.59"**	**1/3.6"**	**1/3.6"**
Pixel number	**48MP**	**12MP**	**12MP**	**48MP**	**12MP**	**12MP**
Single pixel size	1.22μm	1.4μm	1.0μm	1.0μm	1.0μm	1.0μm
Phase detection auto focus	100%	100%	support	100%	NA	support
	iPhone 14 Pro Max / iPhone 14 Pro			**——iPhone 14 Plus / iPhone 14——**		
	Main	**Ultra-Wide**	**Telephoto**	**Main**	**Ultra-Wide**	**Telephoto**
CIS	**IMX803**	**IMX633**	**IMX714**	**IMX703**	**IMX772**	**IMX714**
Color filter array	QBC	Bayer	Bayer	Bayer	Bayer	Bayer
Sensor size	**1/1.3"**	**1/2.55"**	**1/3.6"**	**1/1.65"**	**1/3.6"**	**1/3.6"**
Pixel number	**48MP**	**12MP**	**12MP**	**12MP**	**12MP**	**12MP**
Single pixel size	1.22μm	1.4μm	1.0μm	1.9μm	1.0μm	1.0μm
Phase Detection Auto Focus	100%	100%	support	100%	NA	support

Source: Apple, Hubweb.cn, BOCOM Int'l

Tracing back to the history of Willsemi, we think although acquisition played an important role in its early days of growth, the company has shown the capability of developing more advanced technology after acquisition. As a company, Willsemi started with business focusing on analog IC distribution. The company expanded its business to CIS field via a series of acquisitions, with the most important ones being the acquisitions of OmniVision and Vision Source. By 2018, Willsemi acquired 100% stake of OmniVision through four acquisitions. In the same year, Willsemi completed the acquisition of SuperPix Micro Technology, whose CIS business held a high market share in the domestic low-end smartphone market. With the acquired IPs and synergies across different mobile handset components, Willsemi developed a wide range of CIS products in both high-end and low-end smartphone categories.

We notice that most of Willsemi's advanced product updates, under the name of OmniVision, happened after the completion of acquisition of OmniVision in recent years. We think Willsemi now has the technical know-how to further innovate and compete in a wide range of mobile and vehicle products.

Figure 49: Summary of major acquisitions of Willsemi

Disclosure date	Subject of agreement	Target company	Amount of contribution	Currency unit	Share acquired	Purpose of acquisition
2018/7/5	Seagull Strategic Investments A1/ C1/ C1 International	OmniVision	39.65	US$ m	1.9543%	The acquisitions further deepen the cooperation between the company and OmniVision, allowing Willsemi to further expand the customer base, and enrich the company's product types.
2018/7/14	Shanghai Qing'en Asset Management	OmniVision	25.56	US$ m	1.97%	
2018/8/15	NA	OmniVision	13,023	RMB m	85.53%	Willsemi becomes the largest shareholder of OmniVision
	NA	Vision Source	255	RMB m	79.93%	Vision Source owns 53.85% of SuperPix.
	NA	SuperPix Micro Technology	234	RMB m	42.27%	SuperPix CIS business has a high share of the domestic low-end smartphone market. So far, Willsemi has 96.12% of the shares of SuperPix.
2018/12/4	Xinneng Investment, Xinli Investment	OmniVision	1,687	RMB m	10.55%	Xinneng Investment and Xinli Investment are entities specially set up to invest in OmniVision, holding 10.55% equity of OmniVision. The acquisition further enriches the product categories of Willsemi's IC design business, and brings high-quality customer resources in the fields of smartphones, surveillance, automobiles and healthcare. **So far, Willsemi has 100% of the shares of OmniVision.**
2019/7/18	Vision Source	Vision Source	64.53	RMB m	20.07%	After the company acquired the remaining 20.07% shares of Vision Source, Vision Source became a wholly-owned subsidiary of Willsemi, thus realizing further holding of Superpix. At this point, Willsemi has 100% of the shares of Vision Source.
2020/4/15	Creative Legend Semiconductor	Synaptics Incorporated's TDDI business	120	US$ m	70%	Acquiring Synaptics's Asia-based single-chip LCD touch and display driver IC (DDIC) business realizes the coordinated development of the company in various product fields, so as to better adapt to the more complex product requirements of the future terminal market in the field of image sensors and touch and display chips. **At this point, Willsemi has 100% of the shares of Synaptics's TDDI business.**

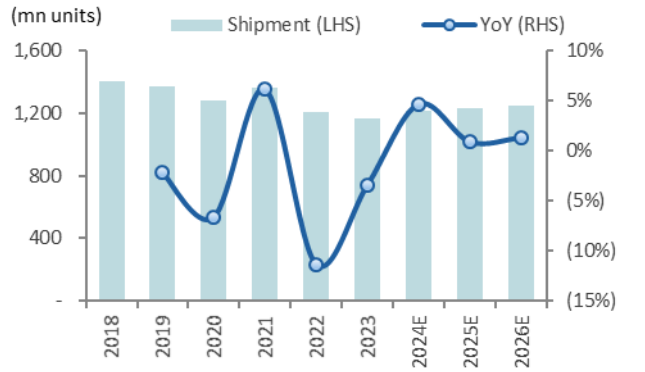
Source: Willsemi, BOCOM Int'l

Smartphone market recovery drives demand for CIS

We believe the global smartphone market could turn around from two consecutive years of negative shipment growth in 2024. We expect global smartphone shipments to grow by 6% and 1% YoY in 2024 and 2025, respectively, mainly due to cyclical demand recovery and possible new demand from AI phones. Whether the concept of AI phone is a short-term marketing phenomenon or long-term growth driver remains to be seen. Yet, we think the trend of recovery in smartphone market could continue into 2025.

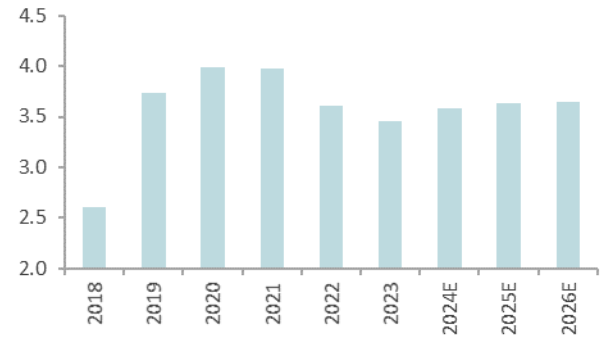
We also think the average number of CIS devices on each phone could recover amid the shipment recovery, as smartphone users tend to upgrade their phones in a product upcycle. We predict that the number of cameras per smartphone to regrow to 3.7 in 2024 after two years of negative growth. According to Frost & Sullivan, at a 4% CAGR from 2022 to 2027, global smartphone CIS market size is expected to grow from US$12.3bn to US$15.1bn.

Figure 50: Global smartphone shipment to recover in 2024



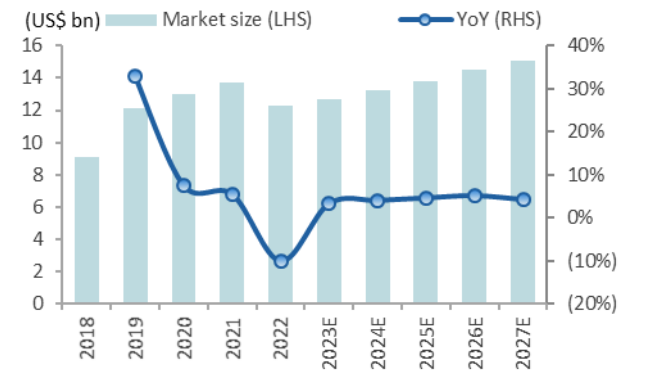
Source: IDC, BOCOM Int'l estimates

Figure 51: Camera per smartphone could rebound in 2024E



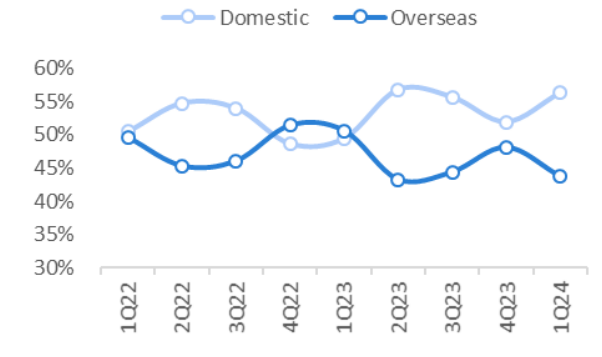
Source: BOCOM Int'l estimates

Figure 52: Global Smartphone CIS market size



Source: Frost & Sullivan, BOCOM Int'l E= Frost & Sullivan estimates

Figure 53: Global smartphone shipment by domestic/overseas brands



Source: IDC, BOCOM Int'l

Amid the smartphone shipment recovery, we also see the resurgence of domestic smartphone OEMs. Huawei, as one of the major contributors of volume growth, is expected to gain market share with its return to the high-end smartphone market. According to IDC, in 2023, shipment of domestic smartphone brands (Huawei, OPPO, vivo, Xiaomi, Transsion) grew 0.3% YoY, higher than that of overseas brand (Apple and Samsung) at -5.6%. We expect this trend to continue in the next 18 months as Android demand growth might outpace iPhone. According to IDC, domestic OEMs' (Xiaomi, Huawei, Vivo, etc.) combined market share reached 56% in 1Q24 from 49% in 4Q22.

Premiumization drives higher OmniVision ASP

As the mobile handset business enters recovery phase and shipment of smartphone starts to rebound, we think smartphone product could re-enter into a premiumization cycle. In the 2022-23 downcycle, Android phones experienced 2 years of camera downgrade. We believe this trend could reverse as we have seen a price hike of Huawei and Xiaomi's new models launched in 2024 compared to their 2023 models. In 3Q24, Huawei launched its first tri-foldable smartphone model, Mate XT, with MSRP starting from RMB19,999, doubled from its previous premium model, P70 Ultra. The main cameras of the flagship models of Huawei and Xiaomi have been upgraded in parameters such as sensor size and single pixel size. As one of the major camera suppliers, we think OmniVision could benefit from this premiumization trend. According to Willsemi, revenue contribution from its premium CIS model with 50MP resolution exceeded 60% in 2023. In this regard, in addition to volume improvement, OmniVision stands to also benefit from ASP hike during the product upcycle.

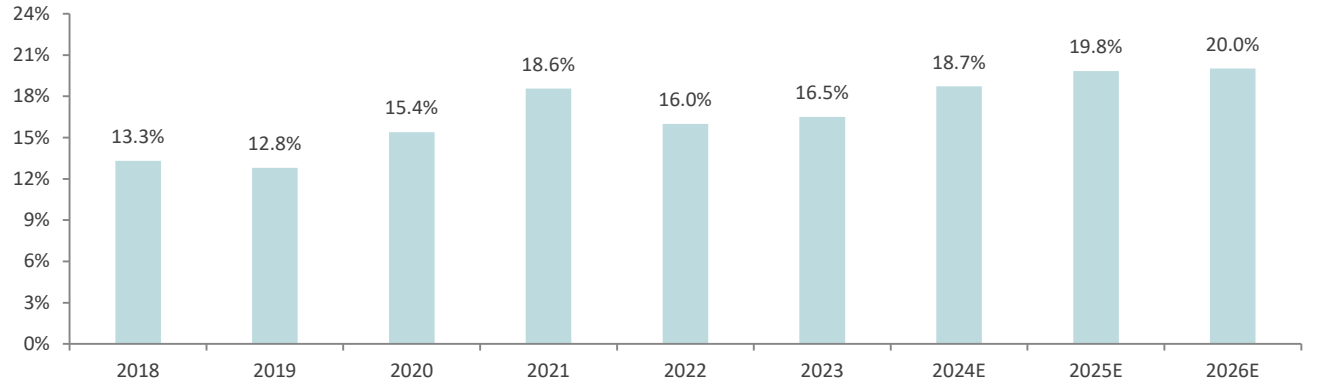
Figure 54: OmniVision's smartphone CIS enter the main camera of Android flagship

Models	CIS	Sensor size	Resolution	Single pixel size	Launched in	Starting Price (RMB)
HUAWEI Pura 70 Ultra	IMX989	1	50MP	1.6μm	2024/5	9999
HUAWEI Pura 70 Pro+	OV50H	1/1.31	50MP	1.2μm	2024/5	7999
HUAWEI P60 Pro	IMX888	1/1.43	48MP	1.12μm	2023/3	6988
HUAWEI P60	IMX789	1/1.43	48MP	1.12 μm	2023/3	4488
Xiaomi 15 Pro	OV50K	1/1.3	50MP	1.2μm	2024/10	NA
Xiaomi 14 Ultra	LYT-900	1/0.98	50MP	1.6μm	2023/10	6499
Xiaomi 14	OV50H	1/1.31	50MP	1.2μm	2023/10	3999
Xiaomi 13 ultra	IMX989	1	50MP	1.6μm	2023/4	5999
OPPO Find N3	LYT-808	1/1.43	48MP	1.12 μm	2023/10	9999
Telephoto of OPPO Find N3	OV64B	1/2	64MP	0.7 μm	2023/10	9999
vivo X100s Pro	IMX989	1	50MP	1.6μm	2024/5	4999
Telephoto of vivo X100s Pro	OV64B	1/2	64MP	0.7μm	2024/5	4999

Source: Public data, Huawei, Xiaomi, OPPO, vivo, BOCOM Int'l

Driven by (1) supply chain localization and technological improvement; (2) resurgence of domestic handset OEM amid global demand recovery and (3) product premiumization, we model Willsemi/OmniVision's global market share in smartphone CIS to grow from 16.5% in 2023 to 20.0% in 2026 and remain in the No.3 position behind Sony and Samsung. We predict Willsemi's smartphone CIS revenue to grow from RMB7.16bn in 2023 to RMB13.08bn in 2026, corresponding to a 22.3% CAGR.

Figure 55: OmniVision global market share on smartphone CIS in value terms shows steady growth



Source: Willsemi, BOCOM Int'l estimates

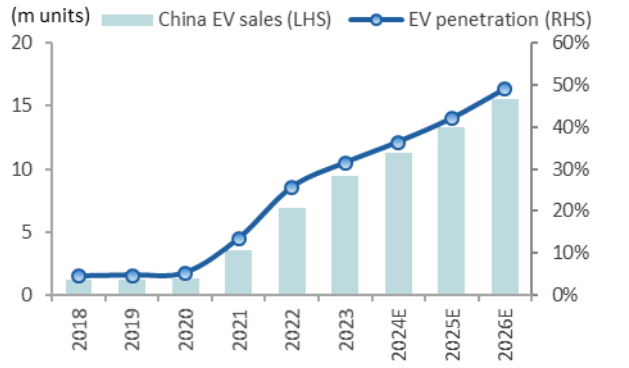
EV Drives Demand Surge for Auto-Related CIS

As Willsemi's second-largest downstream exposure, automobile market has been experiencing a revolution of electrification and vehicle intelligence upgrade. An electric vehicle (EV) typically consumes more electronics products, including CIS, compared to an ICE vehicle. Also, as the level of autonomous driving continues to improve, we think CIS demand from automobile application could more than double from 2022 to 2026. Our check shows that a typical newly launched EV model could equip more than 10 CIS modules, much higher than an ICE vehicle. As Willsemi has a relatively complete product portfolio in auto space and domestic OEMs occupy a large portion of EV market, we model Willsemi/OmniVision auto CIS revenue to grow from RMB4.13bn in 2023 to RMB7.65bn in 2026, corresponding to a 23% CAGR.

EV penetration continues to surge, driving higher demand for CIS

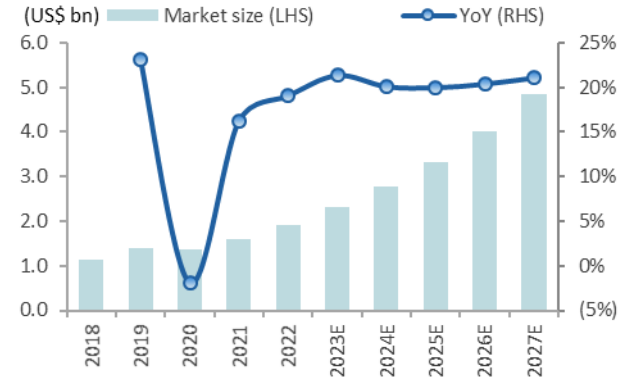
Global EV penetration surges, increasing the demand of CIS. According to Marklines, the global total sales of EVs in 2023 was 13.8m units, increasing 33% YoY and accounting for 17% of the overall vehicle market. China EV market penetration is far ahead of the global average. According to CAAM, China's EV sales grew by 165%/96%/37% in 2021-2023 respectively, and the EV penetration rate also increased to 31% in 2023 from 13% in 2021. We expect the China EV penetration rate to grow to 49% in 2026. We also believe the increase of EV penetration will continue to be the major driver for demand of auto CIS.

Figure 56: China EV sales vs EV penetration



Source: CAAM, BOCOM Int'l estimates

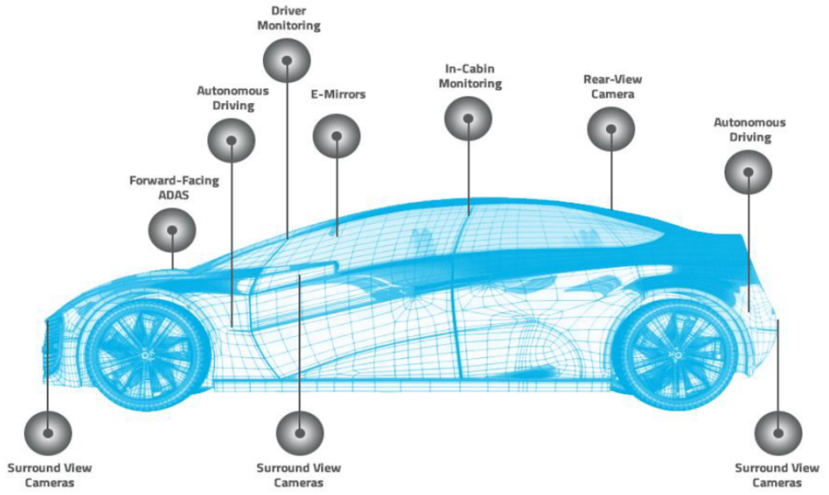
Figure 57: Global auto CIS market size



Source: Frost & Sullivan, BOCOM Int'l E= Frost & Sullivan estimates

We think an EV is normally equipped with more than twice as many cameras comparing to an ICE vehicle. According to our survey, the number of cameras in an ICE vehicle is normally less than three, while that per EV could be much higher depending on the features on vehicle. For example, Xiaomi SU7 is equipped with 11 exterior cameras, including 2 front-view cameras, 4 side-view cameras, 1 rear-view camera, and 4 surround-view cameras. Li Auto's L9 Ultra 2024 also is equipped with 11 exterior cameras. As the features of ADAS and advanced-level autonomous driving set to materialize, we believe that camera and related image sensor products could continue to upgrade.

Figure 58: Automotive image sensor applications



Source: Willsemi, BOCOM Int'l

Another important trend we observe is that the demand for auto CIS is consistently robust across different tiers of vehicles. From Xiaomi SU7 with MSRP in the RMB200K+ range to Li Auto's L9 with MSRP between RMB410K and 440K, we see that the amount of cameras/CIS modules is consistent, which gives us further confidence that CIS demand could be robust as EV shipments and average camera per car continue to rise.

We believe that the increase in the number of cameras on EV and the penetration rate of EVs could benefit CIS vendors, especially domestic CIS manufacturers including OmniVision. According to Willsemi, the average CIS per car had increased from 1.6 in 2018 to 2.9 in 2022 and is expected to increase to 7 in 2027. The electrification and intelligence upgrade of vehicles have pushed auto manufacturers to continuously increase their investment in autonomous driving which brought new development opportunities to the auto CIS industry. According to Frost & Sullivan, the global market size of auto CIS is expected to grow from US$1.91bn in 2022 to US$4.86bn in 2027, or 20.6% CAGR. The growth is expected to maintain at more than 20% YoY in 2023-27.

Figure 59: Number of cameras of the latest EV models is consistent across tiers of automobiles

Brand	Series	Price (RMB)	Front	Side	Behind	Surround	Total
AITO	M9 (BEV)	509,800-569,800	2	4	1	4	11
	M9 (PHEV)	469,800-529,800	2	4	1	4	11
	M7 (New)	469,800-569,800	2	4	1	4	11
	M5 (New)	269,800-279,800	2	4	1	4	11
Li Auto	L6	249,800-279,800	2	4	1	4	11
	L7	301,800-359,800	2	4	1	4	11
	L8	321,800-379,800	2	4	1	4	11
	L9	409,800-439,800	2	4	1	4	11
	MEGA	529,800	2	4	1	4	11
Xiaomi	SU7	215,900-299,900	2	4	1	4	11

Source: AITO, Li Auto, Xiaomi, BOCOM Int'l

Willsemi market share set to rise in auto CIS

We study the auto product portfolio of OmniVision and we think OmniVision has a complete range of CIS product for different automotive applications, including ADAS, in-cabin monitoring, electronic rearview mirrors, and auto cameras. OmniVision products can be used in luxury and compact vehicles with different configurations of resolution, single pixel size and sensor size.

Most recently in 1H24, Willsemi launched OX08D10, a premium product to enhance the company's competitiveness in high resolution product segment. OX08D10 is the first 8MP auto camera with TheiaCel technology, which gives OX08D10 optimized performance in a dark environment with low power consumption. Also, according to Willsemi, OX08D10 has only half of the sensor size comparing to its competitors. The OX08D10 is compatible with the NVIDIA Omniverse platform for autonomous driving and could also integrate with various Qualcomm's Snapdragon platforms for autonomous driving and smart cockpit applications. Following the successful launch of the OX08D10, Willsemi released OX05D10, a 5MP CIS product with TheiaCel technology, suitable for high dynamic range (HDR) and LFM (LED Flicker Mitigation) applications. With different resolution and price, Willsemi's product strategy is to provide a wide range of selection of different auto configuration and BOM budget.

Figure 60: Specs of OmniVision's auto CIS

CIS	Pixel	Single pixel size	Sensor size	Application
OX03A2S	2.5MP	3.2um	1/2.44"	Surround
OX05D10	5MP	2.1um	1/2.48	Surround
OX01J10	1.3MP	3um	1/3.55	Surround
OX08D10	8MP	2.1um	1/1.73	Front
OX08B40	8.3MP	2.1um	1/2.5"	Front
OX08D10	8MP	2.1um	1/2.48"	Front
OX01E10	1.3MP	3um	1/4"	Rear
OX05B1S	5MP	2.2um	1/2.53"	Cabin
OX02C1S	2.5MP	2.2um	1/3.55"	Cabin
OX01H1B	1.5MP	2.2um	1/4.51"	Cabin
OX05B	5MP	2.2um	1/2.53	Cabin
OX05D10	5MP	2.1um	1/1.73	Surround, Rear
OX01E20	1.3MP	3um	1/4"	Surround, Rear
OX01J	1.3MP	3um	1/4"	Surround, Rear
OX03F10	3MP	3.0um	1/2.44"	Rear, Cabin
OX03D4C	3MP	2.1um	1/4"	Surround, Rear, Cabin
OX03J10	3MP	2.1um	1/4"	Surround, Rear, Cabin
OX03C10	2.5MP	3.0um	1/2.6"	Rear, Surround, Cabin

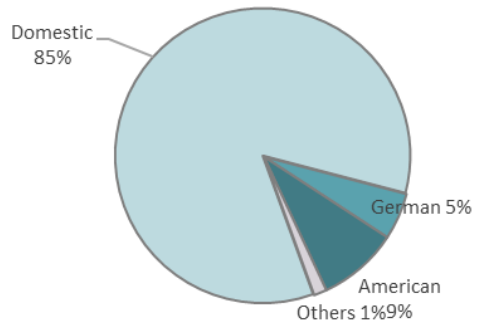
Source: OmniVision, BOCOM Int'l

Similar to the mobile handset industry, Chinese EV OEM brands have the vast majority of market share in China. According to CPCA, the market share of domestic brands reached 85% in 2023. We believe that the high market share of domestic OEMs also provides a good foundation for Willsemi to expand its auto CIS business. In 2023, Willsemi's auto CIS revenue increased 25% YoY. According to Willsemi, its auto CIS shipments (in terms of

number of devices shipped) ranked No.1 in the world for the first time in 1H24, largely driven by the expansion of auto CIS product line and continuous technological catch-up.

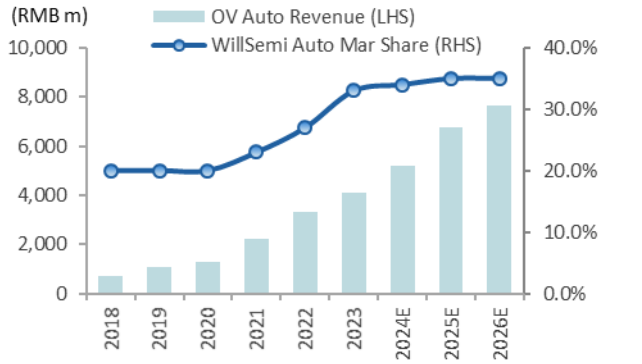
Willsemi's revenue growth from auto CIS reached 72%/49%/25% respectively in 2021-2023, and revenue from auto CIS was RMB4.13bn in 2023, accounting for about 29% of Willsemi's CIS revenue. We estimate that Willsemi's market share of global auto CIS by shipment was 33% in 2023. We expect its auto CIS revenue to grow to RMB7.65bn in 2026, corresponding to a 23% CAGR.

Figure 61: China's domestic EV brands dominates global market (2023)



Source: CPCA, BOCOM Int'l

Figure 62: Willsemi auto CIS revenue and market share



Source: WillSemi, BOCOM Int'l estimates

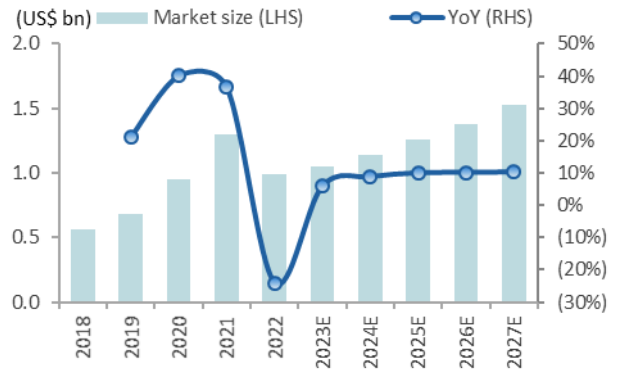
Surveillance Set to Recover in 2025; Medical and Emerging Markets Continue to Prosper

According to Frost & Sullivan, the global surveillance CIS market grew from US$560m in 2018 to US$988m in 2022, with a CAGR of 15.3%, and is expected to further expand at a CAGR of 9.1%, reaching US$1.53bn by 2027.

Willsemi's surveillance image revenue accounted for about 11% of the total image revenue in 2023, much lower than 17% in 2022. The surveillance image sensor revenue in 1H24 also decreased 25% YoY to RMB708m. Traditional surveillance market is driven by government spending on surveillance system and Willsemi's surveillance CIS revenue reached its peak in 2021. Due to reduced government spending budget and relatively saturated market, revenue for Willsemi's surveillance image sensor has been dropping for two consecutive years to RMB1.72bn in 2023. We expect a lackluster demand for traditional surveillance market in 2024. On the other hand, the demand for consumer surveillance, especially export surveillance market, is showing signs of growth.

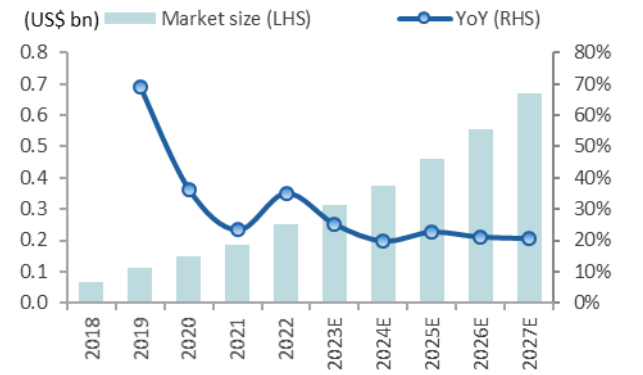
In the short term, we expect Willsemi's surveillance image sensor revenue to bottom in 2024 as revenue has shown sequential decline moderation in recent quarters. In the medium term, we expect a moderate recovery of Willsemi's surveillance image sensor business driven by the progress of the company's high-end product. Products with Nyxel near-infrared achieved excellent near-infrared performance, and we think near-infrared product could provide a technological complement to surveillance system deployed in darker areas. Also, Willsemi's newly launched 4K high-definition high-end products have achieved mass production delivery in 1H24. With that being said, we have limited visibility on demand recovery and we model 2025E/26E surveillance image sensor revenue to be lower than 2023 level.

Figure 63: Global surveillance CIS market size



Source: Frost & Sullivan, BOCOM Int'l E= Frost & Sullivan estimates

Figure 64: Global medical CIS market size



Source: Frost & Sullivan, BOCOM Int'l E= Frost & Sullivan estimates

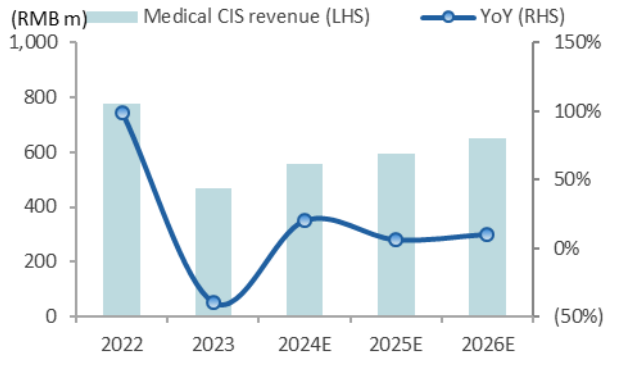
Medical image and AR/VR could be long-term growth driver

Willsemi's medical image sensor revenue accounted for about 3% of its image sensor revenue in 2023. Medical CIS is mainly used in medical cameras for minimally invasive surgery, and the direction of technology upgrade includes higher resolution and better performance. According to Frost & Sullivan, the global medical CIS market grew from US$65m in 2018 to US$250m in 2022, with a CAGR of 40.0%, and is expected to reach US$672m by 2027, with a CAGR of 21.9%. We think medical image, although still a niche market, represents state-of-the-art image processing technology and requires a high technological level. We think participation in the medical image market allows Willsemi to experiment with the most advanced CIS technologies and could bring R&D benefits to the company in the future.

Willsemi's revenue from emerging markets (mainly AR/VR applications) image sensor accounted for about 3% of its image sensor revenue in 2023. We think some market participants could have unrealistic expectations on the demand for AR/VR headset. According to Frost & Sullivan, shipments of AR/VR devices are expected to increase from 10m units in 2022 to 109m units in 2027, an increase of 10 times. However, we have limited visibility of surge of demand of AR/VR headset in near term, and model the growth of this business to be in-line with the growth of the entire image sensor business.

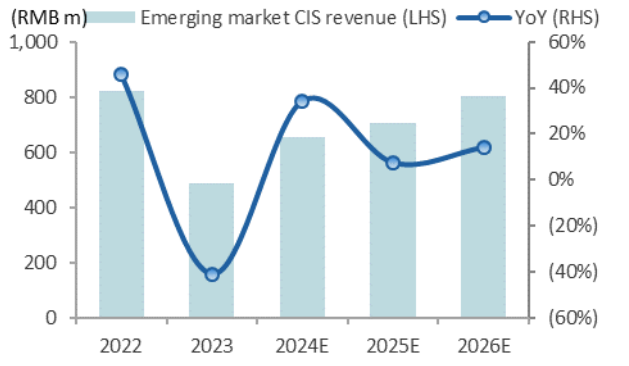
With the inputs from image sensors, the main technologies of AR/VR headset include gesture detection, depth and motion detection, and head and eye tracking. Willsemi has established a new computer vision department to focus on providing industrial automation, robots, logistics barcode scanners and intelligent transportation systems (ITS). According to Willsemi, its AR/VR image sensor products are leading the market in power consumption, HDR, low noise and other performances. Should the demand of AR/VR application improve, we see Willsemi as well positioned in capturing the emerging opportunity.

Figure 65: Willsemi medical CIS revenue



Source: Willsemi, BOCOM Int'l estimates

Figure 66: Willsemi emerging market CIS revenue



Source: Willsemi, BOCOM Int'l estimates

Touch and display business under pressure near term; analog business resumes growth

Willsemi developed some of its technical capability of touch and display business by acquiring companies with expertise in the space. In 2020, Willsemi expanded its product line by acquiring Synaptics' TDDI (Touch and Display Driver Integration) business. In 2021, Willsemi acquired Gigadisplay, a domestic leader in driver IC for flexible AMOLED/AR, to expand its OLED DDIC (Display Driver Integrated Circuit) business. In 2022, Willsemi acquired Zhuhai Siruibo to deploy TED (TCON Embedded Driver) business. Since then, the company has been among the leaders of touch and display industry product cycle and released a series of new products in TDDI, DDIC and TED. The products are applied on smartphone, PC and auto sector.

Although the downstream applications are wide, display and related ICs have been facing a downcycle since 2021, partly due to stiff upstream vendor competition. For Willsemi, touch and display business revenue dropped from 8% of the total revenue in 2021 to 6% in 2023, and we forecast the number could be down to 4% in 2024 and 2025 respectively. In 1H24, Willsemi's touch and display business was down 29% YoY mainly due to ASP pressure. We model the revenue of the company's touch and display business to be down 21% in 2024. We see silver lining of the business as the company reported its new OLED DDIC product has passed qualification process of a major domestic LCD vendor. We model a moderate recovery of the revenue in 2025 and 2026, but we have limited visibility for the touch and display business revenue to reach 2022 level.

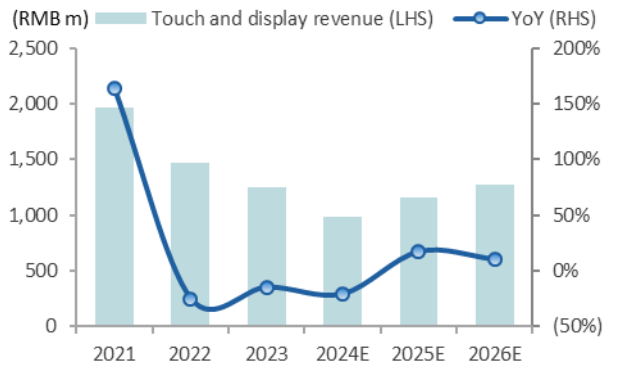
Figure 67: Specs of OV's touch and display product

	Progress
TDDI	• Full product coverage from HD 720P to FHD 1080P, with display frame rates ranging from 60Hz, 90Hz, 120Hz to 144 Hz. • The upgraded version of FHD TDDI solution TD4376 was launched, achieving 1080P FHD resolution and display frame rates up to 144 Hz, and collaborate with a more reliable domestic fab. • Launched TD4165, TDDI for a-Si panel FHD 900RGB*2100 resolution.
TDDI in auto	• It is expected to launch the company's first in-vehicle TDDI product that meets the mainstream market demand specifications in 2H24.
DDIC	• The company has developed DDIC for OLED displays in smartphones such as OD6630 and OD6631.
TED	• The newly launched OD5160 TED (TCON Embedded Driver) chip brings lower power consumption, narrower display backplane, lower carbon emissions and lower cost for notebook display driver solutions.

Source: Willsemi, BOCOM Int'l

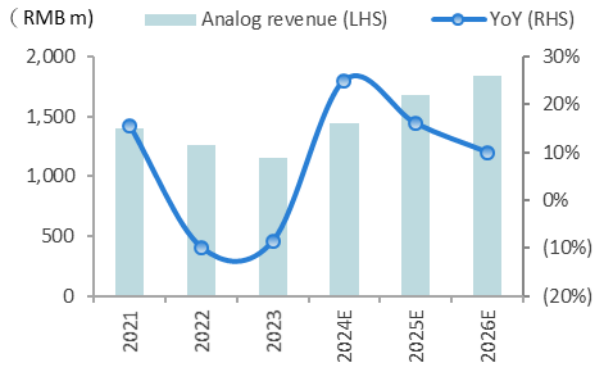
Willsemi's analog business, which consists of products such as Controller Area Network (CAN), Local Interconnect Network (LIN), Serial to De-Serial (SerDes), Power Management Integrated Circuit (PMIC) and System Basis Chip (SBC), mainly provides products related to analog transmission and power management in mobile device and autos. In 2023, analog business accounted for around 5% of Willsemi's total revenue and grew by 25% YoY in 1H24, mainly driven by the downstream inventory re-stocking, as well as market share gain. We model the analog business to grow 25% in 2024. In the long term, we are optimistic that Willsemi could continue to grow this part of business as electrification of automobile industry continues to materialize and penetration of domestic supply chain could rise amid localization theme.

Figure 68: Willsemi touch and display revenue



Source: Willsemi, BOCOM Int'l estimates

Figure 69: Willsemi analog revenue



Source: Willsemi, BOCOM Int'l estimates

In addition to the three main product categories of image sensors, touch and display, and analog device, Willsemi's "3 + N" strategy plans to expand the product portfolio to LCOS (Liquid Crystal on Silicon), MCU (Micro-controller Unit) and services.

Last but not least, Willsemi's semi distribution business, which has low GPM, aims to redistribute IC products that are not designed by Willsemi. In 1H24, semi distribution business grew 13.4% YoY and recorded RMB1.63bn in revenue, or 13.5% of the total revenue. We think this part of the business could provide long-term synergy to company's core business of IC design, and model its revenue and margin to remain relatively flat going forward.

Company Background

Figure 70: Milestones in the history of Willsemi

Year	Event
2007	Company established in Shanghai, China, designing semiconductors for products such as power devices and power IC products.
2013	Acquired Beijing Jinghongzhi Technology Co., Ltd and HK Waching Electronic (Group) Limited for entry into the semiconductor distribution market.
2014	Acquired Beijing Telepath Technologies Ltd. for entry into satellite live broadcast SoC chip design business.
2015	Acquired Wuxi Zhongpu Micro-electronics Co., Ltd. and established Shanghai Weile for entry into radio frequency chips design business.
2016	Founded Shanghai Panju and Shanghai Xijiu for research and development of silicon microphones and broadband carrier chip.
2017	Company listed on Shanghai Stock Exchange.
2017	Established Shanghai Weizimei Electronic Technology Co., Ltd, with a concentration in the R&D of high-performance IC products.
2018	Acquired Beijing OmniVision Technology Co. Limited.
2019	Acquired Beijing Vision Source Technology Development Co., Ltd. to enter the CMOS image sensors business.
2020	Acquired Synaptics Incorporated's Asian TDDI Sector to enter into the LCD touch and display driver integrated chip business.
2021	Purchased 65.77% of Gigadisplay ownership to enter into the Display Driver IC (DDIC) display driver chip area.
2022	Acquired Zhuhai Siruibo to deploy TED business.
2023	GDR issued by Willsemi is listed on the SIX Swiss Exchange.

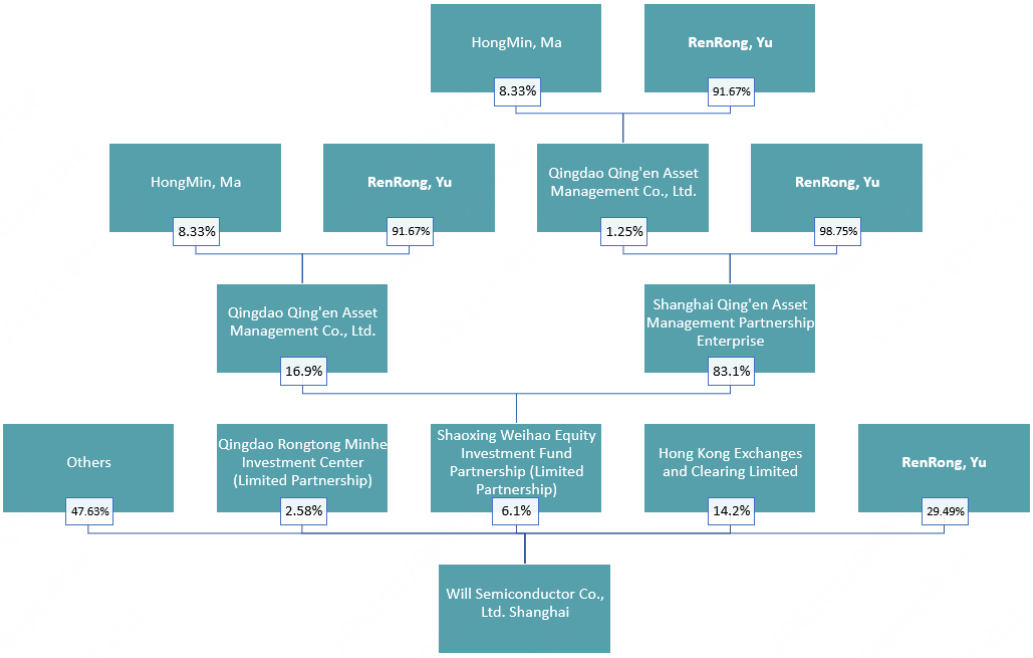
Source: Will semi, BOCOM Int'l

Figure 71: Management team of Willsemi

Name	Biography
Renrong Yu	Chairman and founder of Will Semiconductor Co., Ltd. He also served as the Director and General Manager of Beijing Ominivision Technology Co., Ltd. He holds a bachelor's degree in radio technology from Tsinghua University.
Yuan Jia	Director, Deputy General Manager and CFO of Will Semiconductor Co., Ltd. He also served as the Director of Beijing Ominivision Technology Co., Ltd. and Zhejiang Willsemi Equity Investment Co., Ltd.
Song Wang	General Manager of Will Semiconductor Co., Ltd. He also served as the Manager of Beijing Ominivision Technology Co., Ltd., the Executive Director and General Manager of Siruibo Semiconductor (Zhuhai) Co., Ltd., and the Executive Director and Manager of Beijing Superpix Micro Technology Co., Ltd.
Bing Ren	Board Secretary of Will Semiconductor Co., Ltd. She also served as the Supervisor of Beijing Ominivision Technology Co., Ltd. and Shanghai Weizimei Electronic Technology Co., Ltd.

Source: Will semi, BOCOM Int'l

Figure 72: Shareholder structure



Source: Wind, BOCOM Int'l

Risk Factors

Risks of Will Semi includes:

1) Weaker-than-expected demand from downstream smartphone and auto sector OEMs;

2) Slower-than-expected R&D progress resulting in a slower ramp up in key products;

3) Domestic or foreign customers changing suppliers resulting in a reduce of orders;

4) Higher-than-expected R&D and/or CAPEX of new product development resulting in lower-than-expected margins;

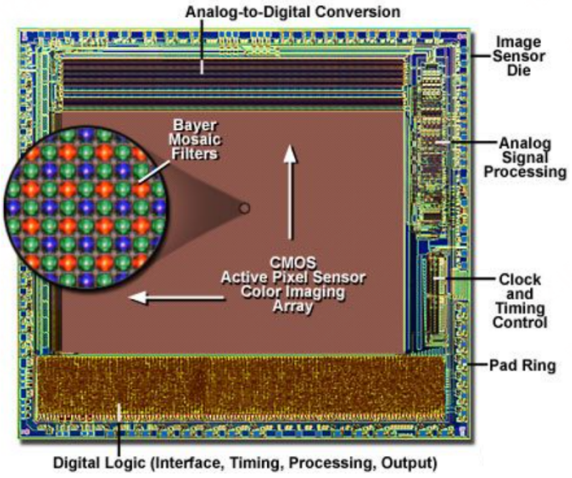
5) Supply chain localization progress slower than expected as domestic product could miss expectation of product qualification;

6) Changes in global situations leading to a higher-than-expected cost of production or lower-than-expected end product sales.

Appendix

What is CMOS Image Sensor (CIS)?

Figure 73: Typical CMOS Image Sensor (CIS) Structure

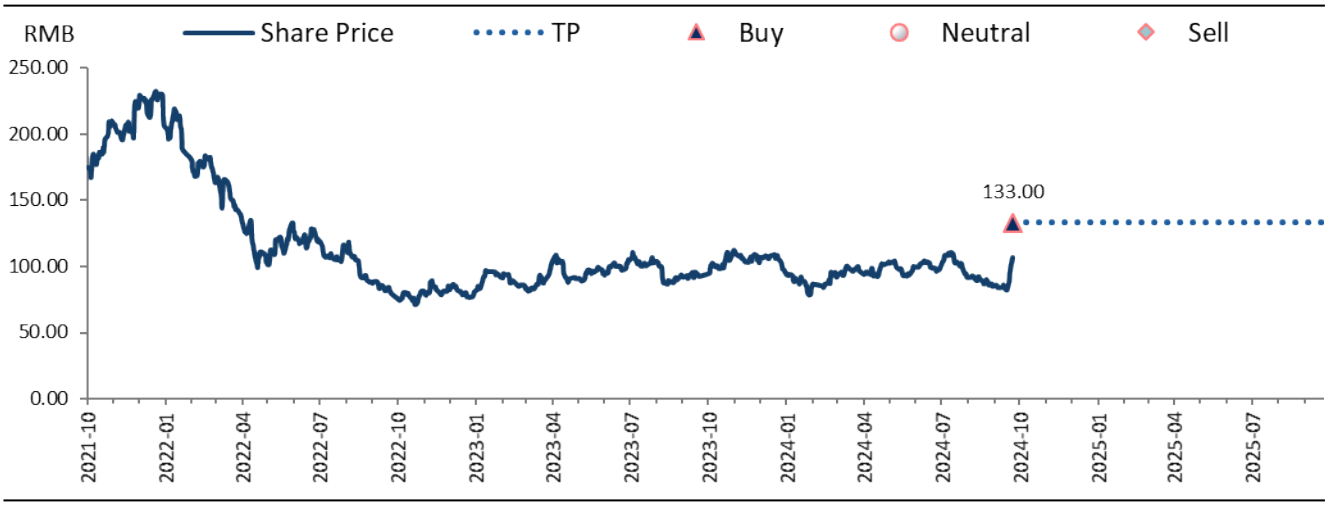


Source: Olympus LS, BOCOM Int'l

A Complementary metal oxide semiconductor (CMOS) image sensor captures photons from light. As photons interact with crystallized silicon in the individual sensor pixels, the energy of photons is converted into electric signals (i.e., voltage). The magnitude of voltage generated is a result of the wavelength and intensity of light on the surface of the sensor pixel. Since sensors typically can only respond to the intensity of the voltage generated, they are monochromatic by nature. Color can be introduced using filter technology (normally a red, green, and blue (RGB) filter). For example, in the above figure, Bayer Mosaic Filters (an array of RGB filters) select red, green and blue color light respectively and synthesize the color representation of the light. After the intensity and color signals pass through CIS/filters, they then enter the analog-to-digital converter which forms a digital representation of what the sensor has captured at pixel level. Digital representation can then be used by higher layer applications.

CMOS image sensors and relevant circuitry are typically integrated into a single chip with main application in mobile handsets. As the frame rate (amount of image presentation generated in a given time) of CIS continue to improve, they are increasingly employed in medical fields and weapon systems. CIS is also more energy effective than CCD (charge-coupled device) image sensors, making them ideal for miniature electronic imaging devices. We also see increasing use of CIS in electric vehicles and industrial machinery, especially in China as the country pushes green revolution and automation.

Figure 74: Willsemi (603501 CH) TP & Rating



Source: FactSet, BOCOM Int'l estimates

Financial Statements

Income statement (RMB m)

Y/E 31 Dec	2022	2023	2024E	2025E	2026E
Revenue	20,078	21,021	26,381	30,457	33,019
COGS	(13,903)	(16,446)	(18,318)	(20,512)	(22,171)
Gross profit	**6,175**	**4,574**	**8,063**	**9,945**	**10,848**
SG&A	(1,281)	(1,090)	(1,345)	(1,523)	(1,684)
R&D	(2,496)	(2,234)	(2,322)	(2,711)	(2,906)
Operating profit	**2,398**	**1,250**	**4,396**	**5,712**	**6,258**
Net finance expenses	(594)	(457)	(457)	(527)	(572)
Other non-op. income, net	(503)	(101)	63	63	63
Pre-tax profit	**1,301**	**691**	**4,003**	**5,248**	**5,750**
Tax	(343)	(148)	(472)	(635)	(702)
Non-controlling interests	32	12	0	0	0
Net profit	**990**	**556**	**3,531**	**4,613**	**5,049**
Net profit for EPS calculation	990	556	3,531	4,613	5,049

Balance sheet (RMB m)

As of 31 Dec	2022	2023	2024E	2025E	2026E
Cash & cash equiv	3,995	9,055	10,824	12,644	14,022
Acc & bills receivable	2,525	4,057	5,092	5,878	6,372
Inventories	12,356	6,322	7,041	7,884	8,522
Other current assets	737	831	1,054	1,216	1,392
Total current assets	**19,613**	**20,264**	**24,010**	**27,622**	**30,308**
PPE	2,540	3,490	4,941	6,221	7,369
Intangible assets	2,018	2,305	1,525	1,009	668
Other non-current assets	11,018	11,684	11,684	11,684	11,684
Total non-current assets	**15,577**	**17,479**	**18,150**	**18,915**	**19,721**
Total assets	**35,190**	**37,743**	**42,160**	**46,537**	**50,029**
Short-term loans	3,632	2,671	3,353	3,871	4,196
Trade and other payables	1,128	1,663	1,852	2,074	2,242
Other current liabilities	5,613	4,734	4,734	4,734	4,734
Total current liabilities	**10,373**	**9,069**	**9,939**	**10,679**	**11,172**
Long-term loans	2,750	2,977	3,737	4,314	4,677
Other non-current liabilities	3,967	4,202	4,064	3,182	2,028
Total non-current liabilities	**6,717**	**7,180**	**7,801**	**7,495**	**6,705**
Total liabilities	**17,090**	**16,248**	**17,740**	**18,174**	**17,877**
Share capital	1,185	1,216	1,216	1,216	1,216
Reserves & other capital items	16,833	20,235	23,161	27,103	30,892
Shareholders' equity	**18,018**	**21,451**	**24,376**	**28,319**	**32,108**
Non-controlling interests	82	44	44	44	44
Total equity	**18,100**	**21,495**	**24,420**	**28,362**	**32,152**

Source: Company data, BOCOM Int'l estimates

Cash flow (RMB m)

Y/E 31 Dec	2022	2023	2024E	2025E	2026E
Net profit	958	544	3,531	4,613	5,049
Depreciation & amortisation	1,045	1,166	1,444	1,457	1,526
Change in working capital	(5,352)	5,232	(1,565)	(1,408)	(964)
Other operating cashflow	1,355	594	531	(883)	(1,153)
Cash flow from operation	**(1,993)**	**7,537**	**3,941**	**3,779**	**4,457**
Capex	(2,306)	(2,350)	(2,115)	(2,221)	(2,332)
Investment	(1,717)	(112)	(141)	(162)	(176)
Other investing cashflow	5	(1)	0	0	0
Cash flow from investing	**(4,017)**	**(2,464)**	**(2,256)**	**(2,384)**	**(2,508)**
Net chg in interest-bearing debt	3,242	(2,009)	914	1,095	688
Dividends paid	(822)	(574)	(269)	(883)	(1,153)
Other financing cashflow	(165)	2,519	(562)	212	(106)
Cash flow from financing	**2,255**	**(64)**	**83**	**425**	**(571)**
Exchange gain/loss	120	51	0	0	0
Cash & cash equiv. at year start	**7,630**	**3,995**	**9,055**	**10,824**	**12,644**
Cash & cash equiv. at year end	**3,995**	**9,055**	**10,824**	**12,644**	**14,022**

Financial ratio

Y/E 31 Dec	2022	2023	2024E	2025E	2026E
Per share data (RMB)					
Core EPS	0.839	0.468	2.906	3.796	4.155
BVPS	15.265	18.054	20.063	23.307	26.426
Margin analysis (%)					
Gross margin	30.8	21.8	30.6	32.7	32.9
EBITDA margin	14.6	11.0	22.4	23.7	23.8
EBIT margin	9.4	5.5	16.9	19.0	19.1
Net margin	4.9	2.6	13.4	15.1	15.3
Profitability analysis (%)					
ROA	2.9	1.5	8.8	10.4	10.5
ROE	5.8	2.8	15.4	17.5	16.7
ROIC	11.6	7.3	23.2	25.9	24.9
Others					
Net debt to equity ratio (%)	13.2	Net Cash	Net Cash	Net Cash	Net Cash
Current ratio (x)	1.9	2.2	2.4	2.6	2.7
Inventory turnover (days)	277.5	207.3	133.1	132.8	135.0
Acc receivable turnover (days)	49.6	57.1	63.3	65.7	67.7
Acc payable turnover (days)	48.6	31.0	35.0	34.9	35.5

Technology

Last Close	Target Price	Upside
RMB 92.89	RMB 107.00	+15.2%

7 October 2024

Maxscend (300782 CH)

Domestic leader in RFFE IC design riding on handset recovery: initiate with Buy

- **We initiate coverage on domestic RFFE IC design leader Maxscend.** We think the company is well positioned as RFFE IC demand recovers driven by the semiconductor supply chain localization theme. We think global demand for RFFE could rebound from its 2022 lows driven by (1) cyclical upturn and demand recovery of mobile handset; (2) technology evolution and increased RF content demand per mobile handset.
- **We see Maxscend's product portfolio continue to expand**, which could further enhance its competitiveness. We estimate Maxscend's China RFFE IC market share to reach 3.8% in 2026 from 2.8% in 2022, highest among its domestic peers. Thanks to its technical break-through in key filter devices, company's module products L-PAMiF and L-FEMiD have been in mass production. Its most sophisticated module, L-PAMiD, has passed client qualification in 2Q24 and could ramp up in production in 1Q25. We also think company's Low Noise Amplifier (LNA) and switch product has similar or better technology comparing to global incumbents.
- **Strategic transition to Fab-lite model intact.** We believe integrating design and manufacturing is the trend for RFFE IC designers. Maxscend has made encouraging progress in two production lines, i.e., 6-inch line with focus on SAW filter and modules and 12-inch line specializing in IPD filter products. Due to its early phase of ramp up in production, we see company's GPM might further compress in 2024. With its module products to ramp up in 2025, we estimate GPM to bottom in 2025. On the other hand, we think Maxscend could maintain a better margin comparing to its global and domestic peers.
- **We initiate coverage with Buy rating, TP RMB107.0 based 54x of 2025E EPS.** We estimate Maxscend to achieve revenue of RMB5.1bn/6.1bn/7.0bn and diluted EPS of RMB1.59/1.98/2.56 (26.8% CAGR) in 2024E/25E/26E respectively. Our target P/E multiple of 54x is higher than company's historic average and higher than sector median, reflecting our positive outlook. 2.0x PEG reflects the strategic importance of semi sector and investor preference towards sector with technological moat.

Financial highlights

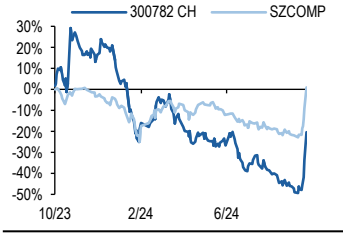
Y/E 31 Dec	2022	2023	2024E	2025E	2026E
Revenue (RMB m)	3,677	4,378	5,099	6,134	7,012
YoY growth (%)	-20.6	19.1	16.5	20.3	14.3
Net profit (RMB m)	1,069	1,122	849	1,056	1,365
EPS (RMB)	2.00	2.10	1.59	1.98	2.56
YoY growth (%)	-50.0	4.9	-24.4	24.4	29.3
P/E (x)	46.4	44.2	58.4	47.0	36.3
BVPS (RMB)	16.27	18.36	19.74	21.49	23.88
P/B (x)	5.71	5.06	4.71	4.32	3.89

Source: Company data, BOCOM Int'l estimates

Stock Rating

BUY

1-year stock performance



Source: FactSet

Stock data

52w high (RMB)	150.70
52w low (RMB)	59.10
Market cap (RMB m)	49,652.49
Avg daily vol (m)	29.68
YTD change (%)	(34.12)
200d MA (RMB)	81.41

Source: FactSet

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Financial Forecast

We estimate Maxscend to achieve revenue of RMB5.1bn/6.1bn/7.0bn in 2024E/25E/26E respectively. In the last semiconductor upcycle, company's revenue reached its historic peak at RMB4.6bn in 2021 before demand materially weakened in 2022, resulting in a revenue decline of 21% to RMB3.7bn. Maxscend regrew its revenue in 2023 at 19% growth rate amid moderate downstream demand recovery and expanding product portfolio. Going forward, we see acceleration of revenue growth and we think the key revenue drivers include:

1) Continuation of ramp up of Xinzhuo's first 6-inch manufacturing line with mass production of DiFEM, L-DiFEM and GPS modules;

2) Early ramp up in production of company's 12-inch IPD platform manufacturing line with production volume climbing for L-PAMiF and LFEM module product. These two products are equipped with company's state-of-the-art Max SAW filter;

3) Company's other RF products (LNA and Switch) could moderately recover amid the semiconductor industry recovery;

4) Going into 1Q25, one of its most sophisticated new module product, L-PAMiD, which integrates the functionality of both receiving and transmitting wireless signals, could ramp up in mass production and contribute meaningful revenue going forward. According to management, the L-PAMiD product has passed key customer qualifications as of 2Q24.

Figure 75: Maxscend's stock incentive program

Revenue (RMB m)	Target			Completion %	
2020/11/30	**100%**	**80%**	**Actual**	**100%**	**80%**
2020	2,495	2,344	2,792	112%	119%
2020-2021	5,445	5,142	7,426	136%	144%
2020-2022	6,050	5,747	11,103	184%	193%
2020-2023	6,655	6,352	15,481	233%	244%
2022/1/28 (terminated)	**100%**	**80%**	**Actual**	**100%**	**80%**
2022	5,800	4,600	3,677	63%	80%
2023/4/30	**100%**	**80%**	**Actual/Est.**	**100%**	**80%**
2023	4,231	4,047	4,378	103%	108%
2023-2024E	9,309	8,702	9,477	102%	109%
2023-2025E	15,402	14,054	15,612	101%	111%
2024/3/29	**100%**	**80%**	**Actual/Est.**	**100%**	**80%**
2024E	5,077	4,654	5,099	100%	110%
2024E-2025E	11,170	10,007	11,233	101%	112%
2024E-2026E	18,177	15,895	18,246	100%	115%

Source: Maxscend, BOCOM Int'l estimates

Maxscend has been rolling out an employee stock incentive program since late 2020. Selected employees are eligible to be rewarded either 100% or 80% of incentivized stock should the revenue achieve different targets. Previously, when the semiconductor industry was in an upcycle, Maxscend's actual revenue would far exceed revenue target.

However, when global semiconductor industry is in a downcycle, company would likely even miss the 80% stock incentive target as it did in 2022. Given the fact that the global semiconductor industry started to recover since 1H23 and mobile handset are among the applications with demand-supply dynamics more favorable to suppliers, we are optimistic about company's chance to achieve revenue target in 2024. We estimate the company to meet the 100% incentive program target in 2024, combined 2024/25, and combined 2024/25/26 respectively.

On the margin side, we estimate that GPM for 2024 to be 41.4%, in-line with 2Q24 GPM but slightly lower than 1Q24 at 42.8%. We estimate GPM to bottom at 40.2% in 2025 and rebound to 41.4% in 2026. The major drivers for company's GPM are: (1) product mix: as module product typically has a lower margin than discrete device, we see the trend of GPM going down in next four quarters; (2) early phase of ramping up new module production resulting in higher depreciation cost and lower production yield. As ramping up continues, we expect the margin to rebound in 2026.

We estimate OPM in 2024E to be 16.6%, lower than 2023's 27.2%, largely driven by higher R&D cost for new products. Our OPM in 2025E is lower than sell side (VA) consensus as our R&D estimation is higher than the market. We think a R&D cost at high-teens (vs. market estimation at low-teens) is essential as company ramps up second production line and L-PAMiD product. We believe higher R&D cost, as a strategic move, could pay off in the future as the company builds up its moat for competition in key module product. We estimate OPM to moderately recover in 2025E at 17.6%, while the R&D cost could stay at elevated levels as company continues to invest in future technologies.

We estimate diluted EPS to be RMB1.59/1.98/2.56 in 2024E/25E/26E respectively, corresponding to 26.8% CAGR for 2024-26E.

Figure 76: Key assumptions of Maxscend

RMB m	2024E	2025E	2026E	3Q24E	4Q24E	1Q25E	2Q25E	3Q25E	4Q25E
Financials									
Revenue	5,099	6,134	7,012	1,390	1,424	1,471	1,515	1,557	1,592
Gross profit	2,112	2,465	2,905	570	580	595	607	621	642
Operating expense	(1,266)	(1,385)	(1,491)	(326)	(326)	(338)	(337)	(346)	(350)
R&D	(1,032)	(1,168)	(1,260)	(267)	(272)	(286)	(287)	(294)	(301)
Sales/marketing/advertising	(49)	(49)	(45)	(13)	(13)	(15)	(15)	(9)	(10)
General and administrative	(172)	(153)	(170)	(47)	(41)	(37)	(35)	(42)	(40)
Operating income	847	1,080	1,414	244	254	258	270	275	292
Net income	849	1,056	1,365	241	258	253	265	269	284
Basic EPS (RMB)	1.59	1.98	2.56	0.45	0.48	0.47	0.50	0.50	0.53
YoY									
Revenue	*16%*	*20%*	*14%*	*(1%)*	*9%*	*24%*	*38%*	*12%*	*12%*
Gross profit	*4%*	*17%*	*18%*	*(13%)*	*3%*	*17%*	*34%*	*9%*	*11%*
Operating income	*(29%)*	*28%*	*31%*	*(45%)*	*(9%)*	*41%*	*58%*	*13%*	*15%*
Net income	*(24%)*	*24%*	*29%*	*(47%)*	*(15%)*	*28%*	*69%*	*11%*	*10%*
Margin									
Gross margin	41.4%	40.2%	41.4%	41.0%	40.7%	40.5%	40.1%	39.9%	40.3%
Operating margin	16.6%	17.6%	20.2%	17.5%	17.8%	17.5%	17.8%	17.7%	18.3%
Net margin	16.6%	17.2%	19.5%	17.4%	18.1%	17.2%	17.5%	17.3%	17.9%
Expense ratio (% of revenue)									
OPEX	24.8%	22.6%	21.3%	23.5%	22.9%	22.9%	22.2%	22.2%	22.0%
R&D	20.2%	19.0%	18.0%	19.2%	19.1%	19.5%	18.9%	18.9%	18.9%
Sales/marketing/advertising	1.0%	0.8%	0.6%	0.9%	0.9%	1.0%	1.0%	0.6%	0.6%
General and administrative	3.4%	2.5%	2.4%	3.4%	2.9%	2.5%	2.3%	2.7%	2.5%
Revenue by segments	**2024E**	**2025E**	**2026E**	**3Q24E**	**4Q24E**	**1Q25E**	**2Q25E**	**3Q25E**	**4Q25E**
Switch	2,295	2,384	2,394	592	589	596	585	597	606
LNA	305	336	284	76	81	83	86	84	83
Transceiver module	2,355	3,214	4,134	622	654	742	795	825	852
Other net	144	200	200	100	100	50	50	50	50
Total	**5,099**	**6,134**	**7,012**	**1,390**	**1,424**	**1,471**	**1,515**	**1,557**	**1,592**

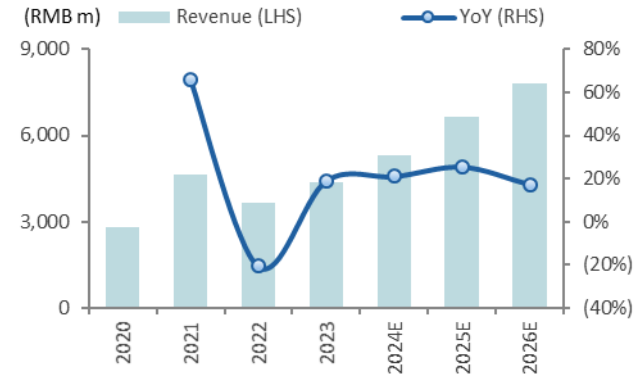
Source: Maxscend, BOCOM Int'l estimates

Figure 77: Financials estimates of Maxscend (BOCOM vs Visible Alpha)

RMB m	2024E	2025E	2026E	3Q24E	4Q24E	1Q25E	2Q25E	3Q25E	4Q25E
Revenue	5,099	6,134	7,012	1,390	1,424	1,471	1,515	1,557	1,592
Consensus VA	5,010	6,173	7,528	1,384	1,322	1,294	1,411	1,682	1,710
diff. %	2%	(1%)	(7%)	0%	8%	14%	7%	(7%)	(7%)
Gross profit	2,112	2,465	2,905	570	580	595	607	621	642
Consensus VA	2,077	2,545	3,155	571	533	530	581	697	707
diff. %	2%	(3%)	(8%)	(0%)	9%	12%	4%	(11%)	(9%)
Operating income	847	1,080	1,414	244	254	258	270	275	292
Consensus VA	887	1,278	1,752	281	246	247	276	350	384
diff. %	(5%)	(16%)	(19%)	(13%)	3%	4%	(2%)	(21%)	(24%)
Net income	849	1,056	1,365	241	258	253	265	269	284
Consensus VA	843	1,173	1,598	267	231	217	245	336	361
diff. %	1%	(10%)	(15%)	(10%)	12%	16%	8%	(20%)	(21%)
Basic EPS (RMB)	1.59	1.98	2.56	0.45	0.48	0.47	0.50	0.50	0.53
Consensus VA	1.60	2.22	3.05	0.52	0.46	0.38	0.48	0.68	0.67
diff. %	(0%)	(11%)	(16%)	(12%)	5%	26%	4%	(26%)	(20%)

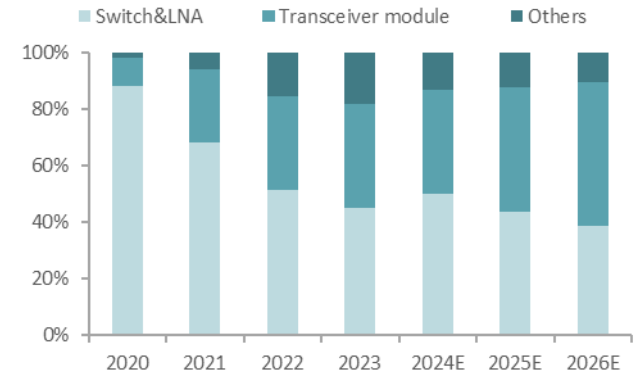
Source: Visible Alpha, BOCOM Int'l estimates

Figure 78: Maxscend's revenue



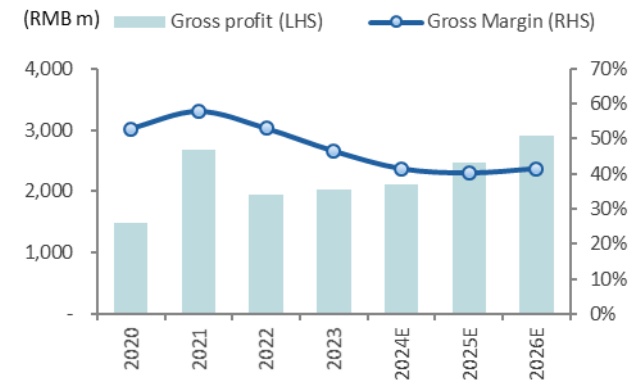
Source: Maxscend, BOCOM Int'l estimates

Figure 79: Maxscend's segment revenue%



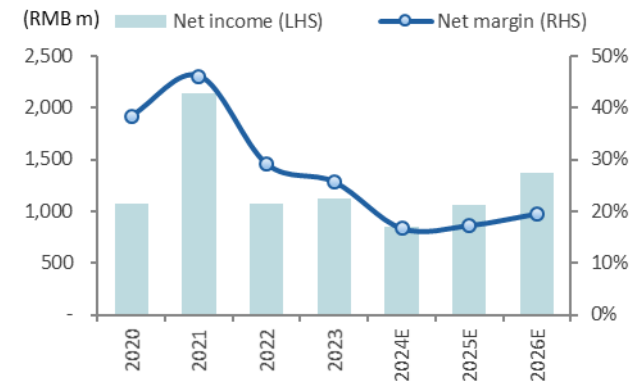
Source: Maxscend, BOCOM Int'l estimates

Figure 80: Maxscend's gross margin



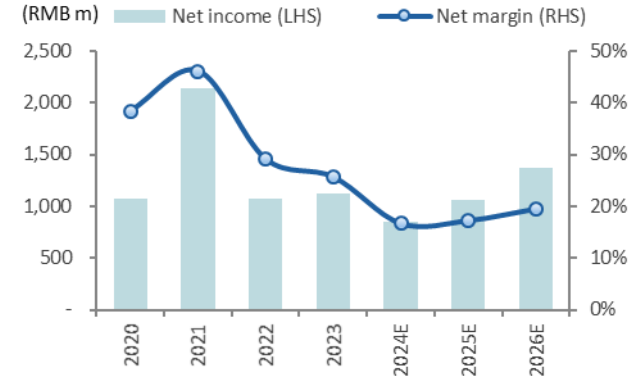
Source: Maxscend, BOCOM Int'l estimates

Figure 81: Maxscend's net income



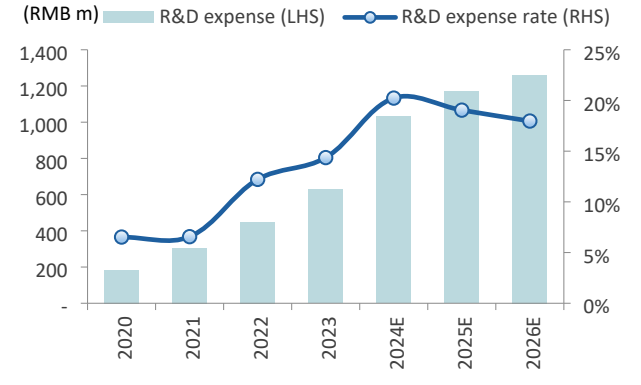
Source: Maxscend, BOCOM Int'l estimates

Figure 82: Maxscend's SG&A expense



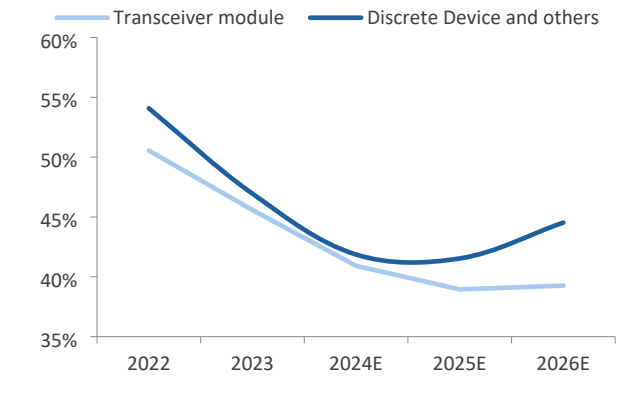
Source: Maxscend, BOCOM Int'l estimates

Figure 83: Maxscend's R&D expense



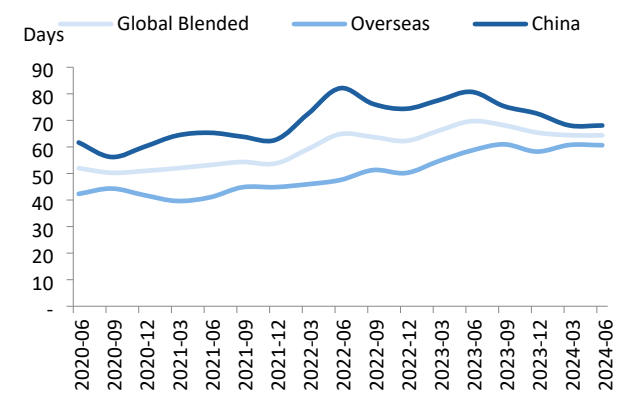
Source: Maxscend, BOCOM Int'l estimates

Figure 84: Maxscend's GPM: module vs others



Source: Maxscend, BOCOM Int'l estimates

Figure 85: Average inventory level of global smartphone vendors



Source: Bloomberg, Apple, Samsung, Transsion, Xiaomi etc., BOCOM Int'l

Valuation

Our price target of RMB107 implies target P/E of 54x on 2025E EPS of RMB1.98. Historically, the company trades at 48x (NTM) P/E on average, with a standard deviation of 19x. The company is now trading below the historical average.

We value Maxcend at 54x P/E, implying 2.0x PEG against our estimates, which is higher than the historic average and higher than domestic IC designer group median at 46.4x, based on the following:

1) After the last peak of semiconductor upcycle in 1H21, we see multiple compression of Maxscend and the broader IC design group. As the financial performance starts to stabilize and as the broader semiconductor industry enters upcycle, we think the multiple could expand;

2) As the company is still in the transition phase to fab-lite business model, we could see possibility of further margin compression in 2024. Although we believe company's top line growth could mitigate some margin pressure, company bottom line is expected to decline in 2024E before it re-grows at 25% in 2025E. We thus think the stock could rerate to a premium to the historic average;

3) Although our net profit estimation is lower than sell side (VA) consensus, we believe that investors could be overly concerned about margin compression. We think margin compression in recent years is results of company's strategic move and a recipe for long-term sustainable revenue expansion. We thus believe that the stock could be oversold as investors prefer defensive over growth stocks in recent market corrections. We also believe that we are more convinced than the market on the margin turnaround outlook in 2025/26. In addition, Maxscend's leadership and the RFFE IC localization demand makes us give a **Buy** rating;

4) The historic average of 47.5x NTM PE has weighed in the industry downcycle period in 2022-2023. As the visibility of EPS growth rate going forward is more transparent, we think a premium of multiple could justify the current status of semi cycle. We also think 2.0x PEG corresponding to 54x 2025 PE reflects the strategic importance of domestic semiconductor sector and investors' willingness to pay premium for company with technological moat;

5) We think the company could maintain its position as domestic RF IC leader in the long term and could further benefit from industry chain localization. We thus think company could trade a premium with respect to IC designer group. We think multiple could further expand once investors see margins stabilize, which we estimate could happen in 2025.

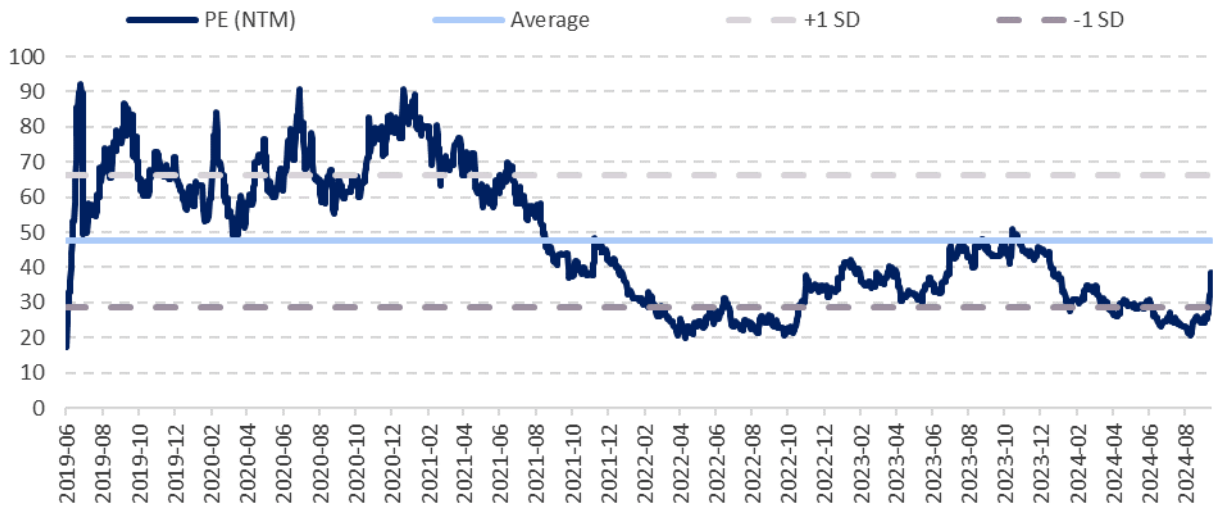
We think near-term upside catalysts for the stock include:

1) Design-win with a major smartphone vendor. Maxscend's module products, especially L-PAMiD, becoming the primary solution for a domestic smartphone could drive the stock for the upside;

2) Innovation breakthrough of domestic smartphone. Sales of smartphone surge due to launch of certain star smartphone model could ignite market's interests on smartphone supply chain players;

3) Tighter import restriction on foreign supply chain. Domestic supply chain players could benefit as localization progress accelerate.

Figure 86: Maxscend's P/E band (forward 12 months)



Source: Bloomberg, BOCOM Int'l

Figure 87: Valuation comparison

Ticker	Name	Market cap (US$ mn)	Last price (LC)	Price ytd (%)	yoy growth of EPS (24-26E)	PE 2024E	PE 2025E	PEG 2025E	PB 2024E	PB 2025E
Domestic IC design										
603501 CH Equity	Willsemi	18,549	107.20	0%	20%	36.8	28.2	1.4	5.3	4.6
300782 CH Equity	Maxscend	7,074	92.89	(34%)	27%	58.4	46.9	1.7	4.6	4.1
688041 CH Equity	Hygon	34,203	103.28	46%	35%	136.6	99.8	2.8	11.8	10.6
603986 CH Equity	GigaDevice	8,384	88.37	(4%)	37%	52.6	35.3	1.0	3.6	3.4
300661 CH Equity	SGMICRO	6,387	95.00	7%	47%	97.9	62.6	1.3	10.6	9.3
600460 CH Equity	Silan	5,363	22.62	(1%)	75%	113.7	46.4	0.6	3.0	2.9
603290 CH Equity	Starpower	3,112	91.25	(29%)	18%	24.7	20.3	1.1	3.1	2.9
688052 CH Equity	Novosense	2,412	118.80	(29%)	N/A	N/A	195.1	N/A	2.8	2.7
688153 CH Equity	Vanchip	2,225	36.32	(45%)	33%	46.2	34.1	1.0	3.7	3.0
Median						55.5	46.4	1.2	3.7	3.4
Overseas IC design										
NVDA US Equity	Nvidia	2,978,923	121.44	145%	31%	42.0	29.4	0.9	30.8	16.2
AVGO US Equity	Broadcom	805,674	172.50	55%	22%	35.2	27.3	1.2	12.1	10.4
AMD US Equity	AMD	265,561	164.08	11%	47%	47.1	29.4	0.6	4.4	4.1
QCOM US Equity	Qualcomm	189,436	170.05	18%	10%	16.7	15.1	1.5	7.4	6.2
MRVL US Equity	Marvell	62,470	72.12	20%	52%	49.0	28.6	0.6	4.4	4.3
Median						42.0	28.6	0.9	7.4	6.2
Semi foundry										
2330 TT Equity	TSMC	783,780	957.00	61%	23%	23.1	18.1	0.8	5.9	4.8
981 HK Equity	SMIC	33,051	20.85	5%	30%	34.7	24.6	0.8	1.1	1.0
GFS US Equity	GlobleFoundries	22,359	40.25	(34%)	44%	30.7	22.1	0.5	1.9	1.7
1347 HK Equity	HH Grace	5,717	20.90	11%	65%	45.5	22.6	0.3	0.8	0.7
Median						32.7	22.3	0.6	1.5	1.4
Smartphone parts										
300433 CH Equity	Hnlens	14,519	20.45	55%	21%	26.2	20.4	1.0	2.1	2.0
002241 CH Equity	Geortek	11,037	22.67	8%	27%	29.5	22.3	0.8	2.3	2.2
300207 CH Equity	Sunwoda	5,826	21.96	49%	53%	25.3	19.7	0.4	1.7	1.5
2018 HK Equity	AAC	4,921	31.90	38%	(1%)	21.0	16.2	(13.8)	1.5	1.3
002456 CH Equity	Ofilm	4,692	9.95	14%	1%	57.5	36.4	63.2	7.9	7.5
300136 CH Equity	Sunway	3,198	23.20	(2%)	27%	30.5	23.2	0.8	2.9	2.6
Median						27.8	21.4	0.8	2.2	2.1
CMOS										
005930 KS Equity	Samsung	279,195	61,500.00	(22%)	22%	11.2	8.5	0.4	1.1	1.0
6758 JT Equity	Sony	121,159	2,777.50	4%	15%	18.3	16.8	1.1	2.3	2.0
000660 KS Equity	SK Hynix	96,661	174,600.00	23%	27%	7.0	4.5	0.2	1.7	1.3
603501 CH Equity	Willsemi	18,549	107.20	0%	20%	36.8	28.2	1.4	5.3	4.6
Median						14.8	12.7	0.8	2.0	1.7
RFFE										
300782 CH Equity	Maxscend	7,074	92.89	(34%)	27%	58.4	46.9	1.7	4.6	4.1
300661 CH Equity	SGMICRO	6,387	95.00	7%	47%	97.9	62.6	1.3	10.6	9.3
688153 CH Equity	Vanchip	2,225	36.32	(45%)	33%	46.2	34.1	1.0	3.7	3.0
688798 CH Equity	Awinic	1,921	57.94	(16%)	105%	66.1	35.8	0.3	3.5	3.2
688536 CH Equity	3peak	1,907	100.96	(31%)	42%	86.5	41.4	1.0	2.3	2.2
Median						66.1	41.4	1.0	3.7	3.2

Source: Bloomberg, BOCOM Int'l Last price as of 2024/9/30

RFFE IC Demand Turns Around amid Broader Handset Recovery and Upgrade

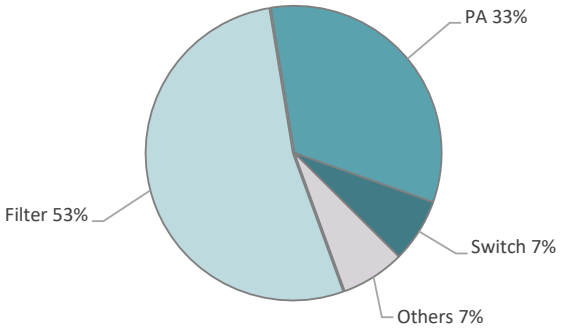
With 55% downstream exposure to the mobile handset, we think the growth of Radio Frequency Front End (RFFE) IC industry is mainly driven by the demand-supply dynamics of mobile handset and average RF content consumed by mobile handset. We see demand of mobile handset starts to steadily recover since 2H23. We think the recovery could continue beyond 2024. Although the market share of domestic vendors is small at the moment, we believe domestic RFFE IC vendors, led by Maxscend, could continue to gain market share amid the broader semiconductor supply chain localization theme. We also believe the recovery of handset market and increased RFFE content as the technology upgrades could benefit Maxscend and other domestic RFFE vendors.

Global RFFE IC market continues to show sign of recovery

The role of RFFE is to transmit and receive modulated radio frequency signal in a wireless communication setting. Within the RFFE circuitry, **Filters** accounts for 53% of the value of RFFE, followed by **Power Amplifier (PA)** at 33%, and **Switch** at 7%, according to Yole. Other elements including **Lower Noise Amplifier (LNA) and up-converter** constitute the rest of 7%. The components could be supplied from RFFE vendors to the clients in the form discrete device (a standalone, independent device) or in the form of module, which is a combination of devices mentioned above.

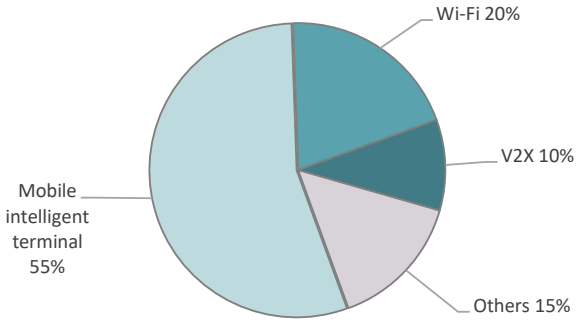
With regard to downstream applications, mobile intelligent terminal (mobile handset) contributes 55% of the application. Wireless LAN (Wi-Fi) and V2X applications accounts for 20% and 10% respectively, according to XYZ research.

Figure 88: Value proportion of RFFE



Source: Yole, BOCOM Int'l

Figure 89: China RFFE downstream application (2022), mobile phone is the main applications



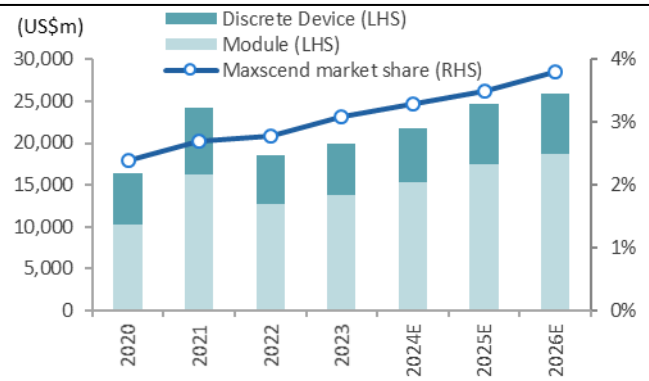
Source: XYZ Research, BOCOM Int'l

China manufactures over 70% of global handset and is the major market of RFFE IC. In 2021, China RFFE IC market exceeded US$24bn amid global semiconductor shortage. We estimate that China RFFE market contracted and bottomed in 2022 at US$18.6bn and could grow to US$26.0bn in 2026 at 9% CAGR. We think demand of RFFE is mainly driven

by (1) potential increase in RFFE content per mobile handset as the mobile technology continues to evolve and (2) recovery of shipment of mobile handset, both of which have shown growth potential in our view.

In terms of product split, more RFFE ICs are shipped in the form of module, from 62.6% in 2020 to 72.1% in 2026, driven by the higher integration requirement of 5G technology. Along with the recovery of global RFFE IC market is the increased market share of Chinese domestic IC designers. We model market share of domestic leader Maxscend to increase from 2.8% in 2022 to 3.8% in 2026.

Figure 90: China RFFE IC market size continues to rise



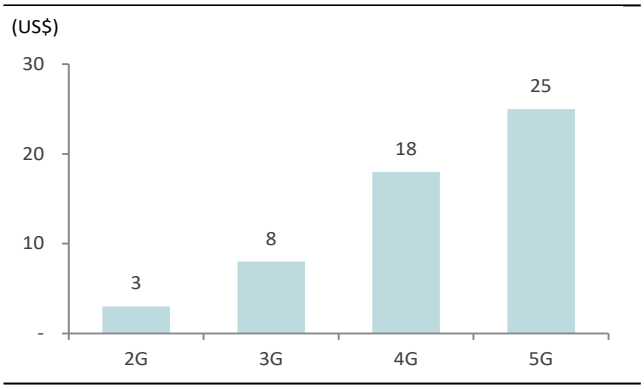
Source: Maxscend, Yole, BOCOM Int'l estimates

RFFE continues to enjoy technology upgrade tailwind

One of the key drivers of the demand of RFFE IC is the increased content used in each mobile handset. As cellular technology continues to evolve, additional frequency band are used to fulfill the ever-growing need for higher data rate demand. Take the 4G to 5G upgrade as an example, minimum bandwidth occupied increased from 20MHz to 100MHz as an implication of adopting transmission technology such as Carrier Aggregation. Governments and regulators also granted additional spectrum to support the demand for higher bandwidth. As a result, RFFE IC value per phone increased from US$18 in 4G era to US$25 on average for a 5G phone, according to Skyworks.

Another evolution we witness is the wider adoption of RFFE IC modules as its technology matures. This is largely due to the fact that RFFE IC module could provide a higher level of integration in a more compacted physical space of mobile handset. We summarize the demand for RFFE IC modules, and we find that the average number of modules needed increased from 1 module per phone in 3G era to between 5 and 9 modules in 5G phone. As the leader of domestic RFFE IC vendor, Maxscend's product is also increasingly leaning towards module from discrete device. We estimate Maxscend's Module sales mix has increased to mid-40s% in 1H24 from mid-30s% in 2023.

Figure 91: Smartphone RFFE value per unit to increase to USD 25 in 2025E



Source: Skyworks, BOCOM Int'l

Figure 92: Challenges of 5G compared to 4G

Technology	Change
Max. carrier frequency	From 2.69GHz to 5GHz
New frequency band	Added n28/n1/n41/n77/n79 etc.
Bandwidth occupied	From 20MHz to 100MHz or above
Transmission Technology	Carrier Aggregation, Massive MIMO
RFFE Technology	5G requires a higher level of integration (normally in the form of module) of RFFE

Source: Prospectus of Vanchip Tech, BOCOM Int'l

Figure 93: Smartphone RFFE value per unit increases (2G to 5G)

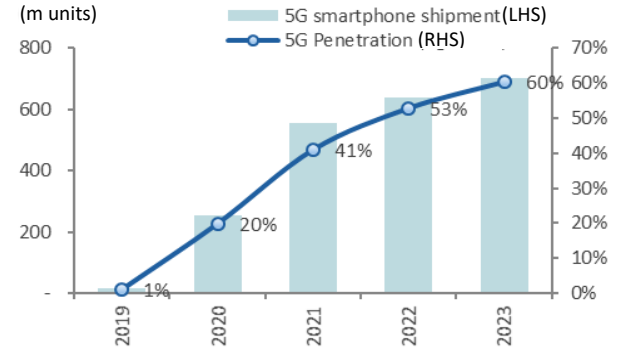
Number of	2G	3G	4G	5G
Frequency band	<5	<9	40	>40
Switch	2	2-4	6-10	30
Filter	2-4	4-8	20-40	40-80
PA	2	3-5	6-10	7-12
RFFE module	NA	1	3-5	5-9
RFFE value per unit	$2-$8	$3-$15	$8-$30	$15-$50

Source: Leadleo, BOCOM Int'l

We believe the upgrade to 5G handset shall continue after a quick surge of 5G handset penetration from <1% in 2019 to 60% in 2023, although the pace has been moderating in recent years. We estimate the 5G penetration could increase to 77% in 2026, further benefitting RFFE IC vendors. According to Yole, the global RFFE market size for 5G technology could improve from US$13.2bn in 2022 to US$23bn in 2028, corresponding to a 9.7% CAGR in the time span.

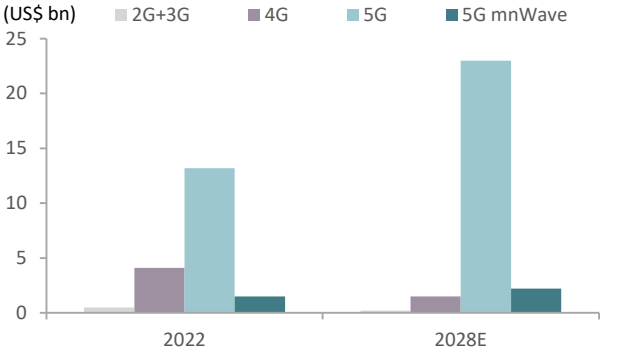
With regard to beyond 5G technology, we believe major upgrade of technology could be beyond 2028, although some progress has been made in so-called 6G technology recently. With that being said, we do anticipate mid-cycle technological upgrade such as the deployment of 5G mmWave to further stimulate the demand for RFFE content.

Figure 94: 5G smartphone penetration rise to 60% in 2023



Source: IDC, BOCOM Int'l

Figure 95: Global RFFE market size by communication technology

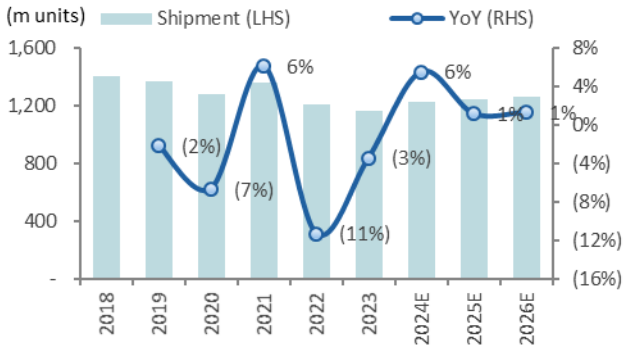


Source: Yole, BOCOM Int'l E= Yole estimates

Global smartphone handset shipment cyclically recovers

The other driver for RFFE content demand is the cyclical recovery of mobile handset shipment. As we discussed in our sector report, we estimate global mobile handset shipment could snap a two-year negative growth streak in 2022 and 2023 to grow at 6% in 2024. Among different handset brands, we think domestic OEMs' market share could increase driven by the strong growth of Huawei.

Figure 96: Global mobile handset shipment to recover in 2024



Source: IDC, BOCOM Int'l estimates

Product Line Expansion Enhances Company's Competitiveness

We study the technical aspects of both Maxscend's discrete devices and module products with comparison to global RFFE leader Qorvo and Skyworks. We conclude that Maxscend has technologically comparable Switch and LNA products to its foreign peers. We think the strength in these two products build a solid foundation for Maxscend to compete in a wide range of module products. We also see company makes great progress in filter product. Company's IPD (Integrated Passive Device) filter has been in mass production in its 12-inch Xinzhuo production line. The company also successfully developed three types of SAW (Surface Acoustic Wave) filters, conventional SAW, Temperature Compensated (TC) SAW, and Max-SAW with their production already ramped up in its 6-inch production line. According to the management, the Max-SAW filter product has state-of-the-art filtering performance comparing to the global incumbents. Thanks to the progress made in the discrete devices, we believe Maxscend is quickly narrowing the gap of module products, in both functions and performance, to global leaders. Company's L-DiFEM, GPS, LFEM, L-PAMiF and L-FEMiD products have been in mass production. Its latest and most sophisticated L-PAMiD module has passed customer qualifications in 2Q24, and mass production is expected to ramp up in 1Q25.

Complete product portfolio leads domestic RFFE players

Among the four discrete devices, Switch and LNA require less sophistication in technology, and we believe Maxscend's products are comparable in technology with respect to Qorvo and Skyworks. Maxscend's major customers include Android smartphone vendors. We believe that includes Xiaomi, Huawei, Oppo, Vivo and Samsung.

Figure 97: Discrete device product Maxscend vs. Qorvo vs. Skyworks. Maxscend has similar performance to Qorvo and Skyworks

Discrete device product comparison with foreign companies: comprehensive			
Product	**Maxscend**	**Qorvo**	**Skyworks**
Switches /Duplexer	**Applications**: 2G/3G/4G, Cellular, WiFi, etc **Insertion loss range**: 0.1-0.9 dB **Isolation range**: 14-55 dB	**Applications**: Mobile products, Wireless infrastructure, Wi-Fi, Automotive, Defense and aerospace **Insertion loss range**: 0.25-6 dB **Isolation range**: 0.33-66 dB	**Applications**: 2G/3G/4G/LTE, Mobile, WLAN, automotive, ISM band radios, infotainment, cable **Insertion loss range**: 0.3-0.8 dB **Isolation range**: 23-64 dB
LNA	**Applications**: GPS, MID/PAD, LTE High to low band receiving **Gain Range**: 0.6-23 dB **Noise Figure range**: 0.5-1.7 dB	**Applications**: 5G/4G/3G/2G/LTE, Amplifiers and Receivers, etc **Gain Range**: 1.3-37.5 dB **Noise Figure range**: 0.3-4 dB	**Applications**: 5G/4G/3G/2G/LTE, Wireless devices etc **Gain Average**: 13 dB **Noise Figure range**: 1.0-1.2 dB

Source: Xonelec.com, lcsc.com, Maxscend, Qorvo, Skyworks, SG Micro, Shenzhen Goodix, RichWave, BOCOM Int'l

A switch/duplexer turns on and off a receiver and transmitter system. There are two major technical parameters for switch performance. Isolation range is a measure of how effectively a switch is turned off. More precisely, isolation range is the attenuation

between the input and output ports of the circuit. A measure of higher number is preferred. While Maxscend's products' upper bound of 55 dB is behind Qorvo and Skyworks' 66 and 64 dB respectively, we think the performance of 55dB in isolation is far more adequate in most applications. (55db means the signal strength is 10^5.5 or 316 thousand times higher when one turns the switch from off to on).

While we do not have the visibility of whether this is an engineering tradeoff by design, we think Maxscend's possible disadvantage in isolation range is made up in insertion loss, which is the amount of energy that the signal loses as it travels through the switch. A lower number of signal lost means less is lost. We find that Maxscend's most sophisticated product only lose 0.1dB comparing to 0.25 dB for Qorvo and 0.3 dB for Skyworks best product respectively. We also find that the range of insertion loss for Maxscend at 0.10-0.90 dB is better than 0.25-6 dB and 0.3-0.8 dB for Qorvo and Skyworks. We also see Maxscend technical advantage when comparing with its domestic competitor. For example, Maxscend's lowest insertion loss is 0.10 dB which is lower than SG Micro's 0.17 dB.

With regard to LNAs, Maxscend's products also show strong technical performance comparing its global peers. As one of the most important parameters, Noise Figure measures the amount of noise that is added to the signal by the circuit. A lower noise figure means the device can amplify the desired signal while maintaining a reasonable noise level, and is thus preferred by downstream customers. We find Maxscend's product noise figure range at 0.5-1.7 dB is very similar if not better than Qorvo's 0.3-4 dB and Skyworks' 1.0-1.2 dB.

Maxscend's filter product, including SAW (Surface Acoustic Wave) filter manufactured by Maxscend's own 6-inch product line has been ramping up in production since 2H22. Its IPD (Integrated Passive Device) filter manufactured by its newly built 12-inch product line has completed major R&D tasks and has started ramping up in production since 2H23. Among different SAW filters, company's newly developed Max-SAW filter received positive feedback from customers after ramping up in production in 2H23. The product rivals Japanese incumbent Murata, and could have similar margin to Murata, according to the management.

Ramping up in module product under way

With the progress in two manufacturing facilities (discussed in detail in next section) and improvement of technical know-how of major discrete device including filter, LNA and switch product, we have seen encouraging progress made in company's RFFE module portfolio.

Figure 98: Comprehensive product comparison: Maxscend vs. Qorvo vs. Skyworks

Products	Maxscend	Qorvo	Skyworks
Switch/ Duplexer	Mobile communications conduction switch, WiFi Switch, etc	Antenna switch modules, RF switches, diversity switches, Wifi switches, etc	High reliability switches, high throw count switches, RF switches, etc
LNA	GPS RF LNA, Mobile Communications Signal RF LNA, TV Signal RF LNA, FM Signal RF LNA, etc	Ultra Low-Noise LNA, High Linearity Low Noise Amplifier Gain Block, High IP3 Dual Low Noise Amplifier, etc	Broadband LNA, high gain LNA with bypass, etc
RF Filters	**SAW filters** (conventional SAW filter, TC SAW filter and Max-SAW all in mass production as of 2Q24 in Xinzhuo's 6-inch production line) **IPD filter** in mass production in 12-inch production line	Discrete RF filters, etc	TC-SAW filters, etc
PA	Mainly integrated in modules	GaN Power Amplifier, High Efficiency Amplifier, etc.	Power amplifiers for Bluetooth Applications, MMMB power amplifiers, 2G/3G/4G/LTE power amplifiers, etc.
RF Modules	**Receiving module (in mass production):** a) DiFEM (Integrating RF switch and filter); b) L-DiFEM (Integrating RF LNA, RF switch and filter); c) GPS (Integrating RF switch and filter); d) LFEM (Integrating RF switch, LNA and filter); e) LNA BANK (Integrating multiple LNAs and RF switch); **Transceiver module:** L-PAMiF (Integrating RF PA, RF switch, filter, LNA **in ramping up production**), L-FEMiD (Integration RF switch, filter, LNA and duplexer in **ramping up mass production as of 2Q24**) L-PAMiD (Integrating RF PA, RF switch, filter, LNA and duplexer**, passed customer qualification in 2Q24, mass production to ramp up in 1Q25**)	Transmit Modules (3G and 4G applications), PA modules (integrated front-end modules), Antenna control solutions, etc.	Cellular modules (2G/3G/4G/5G Front-end cellular modules), etc.

Source: Xonelec.com, lcsc.com, Maxscend, Qorvo, Skyworks, SG Micro, Shenzhen Goodix, RichWave, BOCOM Int'l

At the receiving end, starting from 2H22, Maxscend has been shipping module products including DiFEM, L-DiFEM, GPS module, LFEM and LNA bank module. We believe Maxscend could gain market share from domestic handset OEMs as product design matures. Receiving end module adds relatively low value comparing to transmitter or transceiver module as the moat of technology is relatively low.

New products such as transceiver module L-PAMiF have been ramping up in production since 2H23. We believe the significance of L-PAMiF should not be underestimated as this is the first product Maxscend with PA functionality. We have limited visibility on the quantity of shipment L-PAMiF but we think a successful ramp-up of the L-PAMiF product could mean that the company has been penetrating to the transceiver market.

L-FEMiD product is the first product with the function of duplexer (a more sophisticated discrete device than switch which support simultaneous receiving and transmitting

function). As of 2Q24, L-FEMiD product has passed client qualifications and has been ramping up in production. We are optimistic about the revenue contribution of L-FEMiD in 2H24 and we think a successful production process could be a catalyst for the company's stock price in 2H24.

The most sophisticated module product L-PAMiD, which integrated both PA and duplexer has just passed qualification process of a client in 2Q24 and could start to ramp up in mass production and contribute revenue since 1Q25, according to company management. We think the success of production ramp-up for L-PAMiD is paramount as L-PAMiD consists a complete set of functionalities of transmitting and receiving of wireless links. With Maxscend's previous product, a mobile handset OEM needs to procure additional RFFE product, either from Maxscend or its competitor to form a close wireless link. Should the launch of L-PAMiD becomes a success, which we believe it will, a mobile handset OEM could entirely rely on the L-PAMiD as its sole RF circuitry.

In our opinion, the trend for RFFE sector is for downstream clients (smartphone OEMs) to procure modules instead of discrete devices as mobile device becomes more integrated and compact in space. Although some of Maxscend's current products are focused in receiving modules, which means clients still need to procure transmitter modules, the progress made in Maxscend's products could pave the way for gaining adoption among smartphone OEMs (mainly transceiver module, e.g., L-PAMiD) in the future. As the leading domestic vendor in RFFE IC, we believe Maxscend market share could continue to improve as more product penetrates to the market.

Maxscend leads domestic RFFE vendors to improve in market share

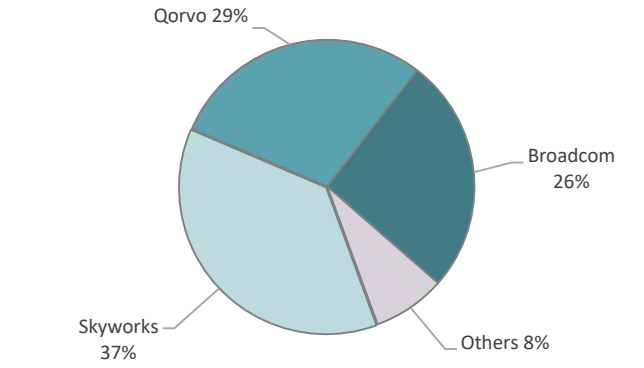
The global RFFE market used to be dominated by foreign RFFE IC vendors in the past especially for high value-added products such as PA and filter related module. In 2020, PA market share was dominated by Qorvo, Skyworks and Broadcom, with a combined market share of 92% according to Reportrc.

Chinese vendors' market share used to be very limited, even for the less advanced switch and LNA devices. As an example, Maxscend's switch product, although considered the most advanced among its domestic peers, only has 5% market share in the switch product category. Lack of domestic supply imposes a technological supply chain risk for downstream smartphone OEM and the entire smartphone supply chain.

With the development of discrete device and module mentioned above, Maxscend and its Chinese peers start to gain market share. As an example, in 2022, although major foreign RFFE IC vendors (Qorvo, Skyworks, Qualcomm, Broadcom and Murata) still collectively owned ~80% of the Chinese RFFE IC market, top 5 Chinese RFFE IC vendors collectively had a total market share of 6.75%, with Maxscend leading the group at 2.79%. With the new module products (L-PAMiF, L-FEMiD and L-PAMiD) starting to penetrate into domestic smartphone OEMs, we estimate Maxscend's China market share could grow to 3.8% (Figure 16) by 2026. According to Maxscend, its customers include major Android smartphone vendors. We believe that includes Xiaomi, Vivo, Oppo and Huawei.

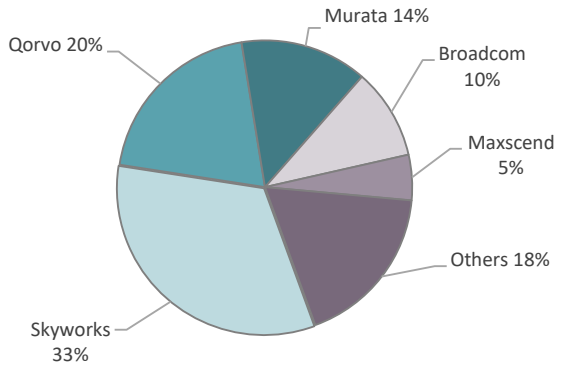
We also believe it sells ICs to foreign smartphone vendors including Samsung. We believe its RFFE products could be equipped in both low-end and high-end models.

Figure 99: Global RFFE PA market share (2020)



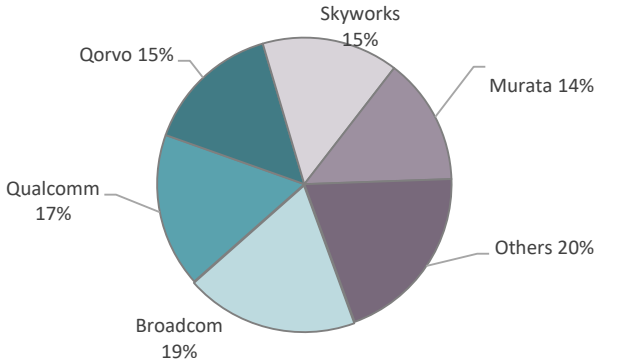
Source: Reportrc, BOCOM Int'l

Figure 100: Global RFFE switch market share (2020)



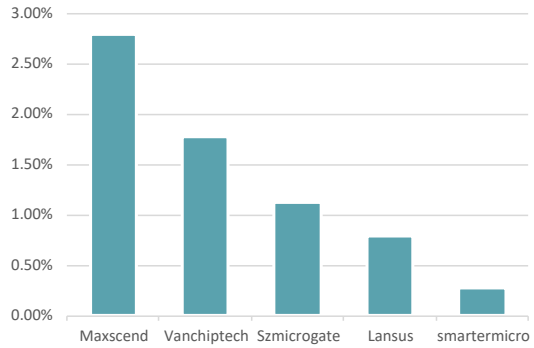
Source: Reportrc, BOCOM Int'l

Figure 101: RFFE market share of Chinese market (2022)



Source: Maxscend, BOCOM Int'l

Figure 102: Maxscend is the Domestic RFFE IC leader in terms of market share (2022)



Source: Maxscend, BOCOM Int'l

Fab-lite Business Model Balances Flexibility and Efficiency, Long-term Financial Impact Controllable

In its earlier days of operations, Maxscend used to outsource most of its production to third-party vendors. The company has started to invest its own manufacturing line since 2021. The company now operates in a "fab-lite" model with two domestic-leading production lines. Its first production line, focusing on 6-inch SAW filter and relevant module products, has been ramping up in production since 2Q22. The company further invested in IPD filter technology and module portfolio in its 12-inch product line, which has started mass production since 1Q24. We think the fab-lite model allows the company to better control its R&D and product quality, and provide more customized product for its clients. To improve operational efficiency, the company still outsources part of the manufacturing to industry partners. We also think the financial impact of building production lines towards company's margin could persist in 2024, yet we do expect GPM to bottom in 2025.

Why fab-lite model?

Fab-lite business model allows the company to balance manufacturing flexibility and the efficiency of product development. Globally, Integrated Device Manufacturers (IDMs) model and fabless model are two major business models for IC design companies. Operating under fab-lite model means that the company will manufacture part of its products in-house while still outsources a significant amount of production to contractors.

We also believe that IDM/fab-lite model is the trend of business model for RFFE IC designers in the future. Globally, unlike digital ID designers who are normally fabless, analogue IC designers, including RFFE IC designers such as Qorvo and Skyworks, typically operate under IDM model. Although transferring from fabless to fab-lite/IDM needs a large amount of financial investment and in the short term could hurt the company's margin, we believe the company is making the right strategic move.

We think, comparing to fabless model, fab-lite has the following advantages:

a) **Better control in R&D progress as manufacturing capability is the key technological know-how in RFFE IC.** Device structure and physical properties are the key technological differentiation and industry leaders typically need to invest in IP in manufacturing capabilities.

b) **Better quality control as most of fabs are digital-circuit-focused.** We believe for key devices such filters and PA, using IDM/fab-lite model could allow vendors to better execute quality control, allow shorter turnaround time, and have better cost management compared to relying on external foundries, which are mostly focused on digital ICs.

c) **Better customizations and product specifications.** RFFE products are typically application and technology specific. IDM/fab-lite model enables RFFE IC designers to better understand client needs and produce better application specific product.

In short, we think it is the industry trend for RFFE IC designer to adopt IDM/fab-lite model to maintain a competitive edge through R&D progress control, supply chain control, product customization, which are all key advantages in the highly competitive RFFE IC industry. We think adopting fab-lite model indicates that the company is making progress in catching up with global leaders in RFFE IC design and exploring new RFFE market.

Also, with fab-lite model, the company still outsources a part of manufacturing (~40% on the long term) to industry partners. This allows the company to efficiently balance the priority differences of products, save production costs and better prepare the company through future semiconductor cycles.

Encouraging progress in Xinzhuo project

As the pillar of fab-lite transition, Maxscend started to invest in the Xinzhuo project in Wuxi, Jiangsu Province since 2020. The near-term goal of Xinzhuo project is to construct two production lines, 6-inch and 12-inch wafer processing technology respectively, to provide in-house manufacturing capability of filters and relevant module products. We think the progress of these two production lines is encouraging and the production facility of these two lines are already helping Maxscend to expand product portfolio as discussed previously.

As of 1Q22, the 6-inch production line has been ramping up in production with focus on SAW filters. 12-inch line is also ready for mass production from 1Q24 specializing in IPD filters. We summarize the detailed progress of the Xinzhuo project as follow:

Figure 103: Maxscend Xinzhuo project progress

Report Date	Project progress
2020	On November 2020, the Company plans to sign the Strategic Cooperation Agreement with the Management Committee of Wuxi Liyuan Economic Development Zone to invest in the construction of Xinzhuo Semiconductor Industrialization Project in Hudai East District, Lake District, Wuxi City, with an estimated total investment of RMB800mn. According to the company, through the construction of wafer manufacturing and packaging test production line, after the completion of the project, the overall process technology capability and module mass production capability of the company in the field of RF SAW filter will be improved. The whole industrial chain layout of RF SAW filter chips and a complete portfolio of RF modules will be achieved and the independent R&D innovation capability and market competitiveness of the company can be improved. The company sees the construction of the Xinzhuo project as an important step of domestic replacement of RF SAW filter chips and RF modules.
2021	2021/3, the company invested an additional RMB2.7bn in the industrialization construction project of Xinzhuo Semiconductor to further expand SAW filter wafer manufacturing and RF module packaging test capacity.
2022	In the first quarter of 2022, the production line of 6-inch filter entered the process line stage, and entered the small batch production stage in the second quarter. As at the end of 2022, the Company's self-built filter production line has fully entered the mass production stage, which add new impetus to the sustainable development of the Company. On the basis of 6-inch filter production line, the company gradually promoted the production and manufacturing capacity of 12-inch IPD filter products by adding advanced equipment and building a professional technical talent team. In 2022, IPD filter products have completed process pipeline and product-level verification and entered into the stage of small batch production.
2023	The filter production line has steadily increased its production capacity since mass production, helping to continuously increase the market coverage and penetration rate of DiFEM, L-DiFEM and GPS module products integrated with self-produced filters in brand clients, and the proportion of RF modules increased from 30.42% in 2022 to 36.34% in 2023. Through continuous upgrading and iteration of materials, design and technology, the company continuously optimizes the performance of enabling products, launches high-frequency and high-performance MAX-SAW filter products, builds core process technology and resource advantages, and lays a good foundation for the company's most challenging transceiver L-PAMiD module products at the RF front end.
2024	12-inch IPD filter production line starts mass production since 1Q24. With the maturity of the design of company's LNA and switch product, the company continues to make progress in module product and provide diversified product portfolio for clients. According to the management, the yield of 6-inch production line has steadily improved as the ramp up accelerates. New product L-PAMiD passed client qualification in 2Q24 and could start shipping to client from 1Q25.

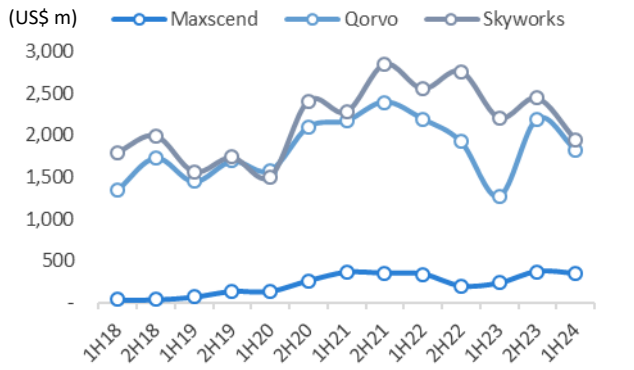
Source: Maxscend, BOCOM Int'l

Going forward, we think the completion of the two production lines could further help accelerate the development of module products. Regarding whether the company will invest in new production lines in the future, we think it is the trend of the sector to integrate manufacturing with design, and Maxscend could have higher autonomy in product design and manufacturing if a PA focused line is developed. Yet, we do not have the visibility that the company would add another manufacturing line imminently.

Long-term profitability still intact

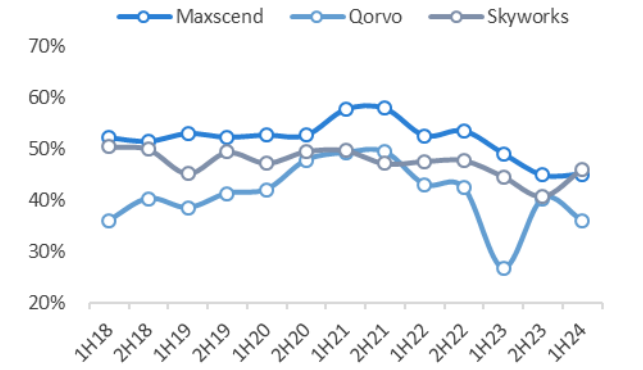
One aspect that concerns investors is the costs of developing new technology and manufacturing line. Since 2H21, we see contraction of Maxscend GPM from 57.8% in 2H21 to 44.8% in 2H23. We believe this is largely due to (1) higher inventory level and weaker pricing power of RFFE IC designers amid global smartphone downcycle; (2) Maxscend's investment in fab-lite model and lower margin in early phase of product ramp up; (3) change of product mix toward module products, which typically have a lower margin than discrete devices.

Figure 104: Revenue comparison with foreign peers



Source: Bloomberg, BOCOM Int'l

Figure 105: Gross margin comparison with foreign peers. Maxscend has higher GPM



Source: Bloomberg, BOCOM Int'l

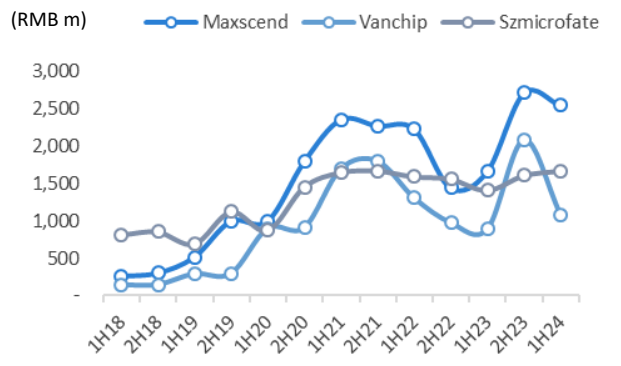
Since 1H18, we see higher gross margin of Maxscend comparing to foreign competitor Qorvo and Skyworks thanks to lower manufacturing cost and favorable product mix. With its revenue and product line start to catch up with Qorvo and Skyworks, we see gross margin of Maxscend converges with Qorvo and Skyworks. As the global mobile handset demand supply dynamics starts to improve, we see Skyworks gross margin recovers in 1H24 while gross margin of Qorvo still fluctuates.

Going forward, we model Maxscend's gross margin contraction to moderate in 2024 and bottomed in 2025 as the company continues to invest in R&D of its key transceiver module products, L-PAMiF, L-FEMiD and L-PAMiD. Given the cost control discipline and cost advantage of Chinese domestic manufacturing supply chain, we expect Maxscend gross margin to be in line or slightly higher than global RFFE IC design leaders' normal

gross margin in the long term. We model Maxscend's gross margin at 41.4% and 40.2% in 2024E/25E respectively. We model Maxscend GPM to rebound to 41.4% in 2026E.

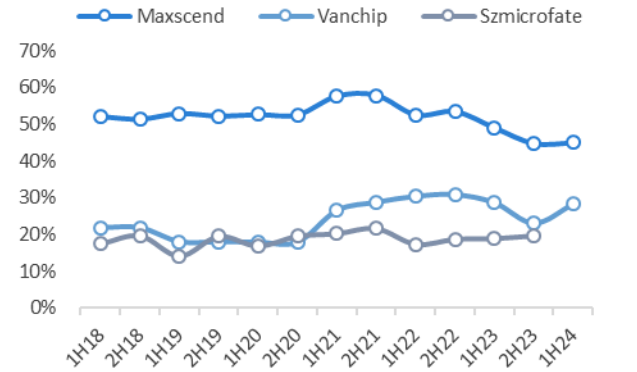
On the other hand, when comparing Maxscend's gross margin with its domestic competitors, we see the company has a much higher margin than the second-tier domestic RFFE vendors including Vanship and Szmicrofate, even when Maxscend's revenue grew much faster from 1H18 to 1H24. We believe this is mainly due to the fact that Maxscend has an advantage in products and technology.

Figure 106: Revenue comparison with domestic peers



Source: Bloomberg, BOCOM Int'l

Figure 107: Superior gross margin compared to domestic peers

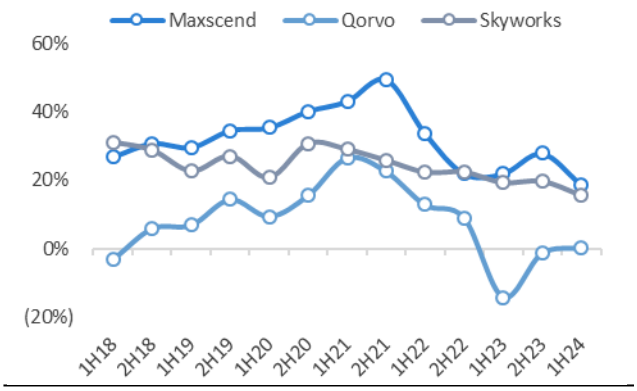


Source: Bloomberg, BOCOM Int'l

Turing to net margin, historically, Maxscend's net margin peaked in 2H21, which align with the peak of the last semiconductor upcycle. The dramatic drop of margin after 2H21 is due to large R&D cost on development of filter and module products. The company's R&D cost as a percentage of revenue has increased from 6.5% in 2020 to 20.5% in 2Q24.

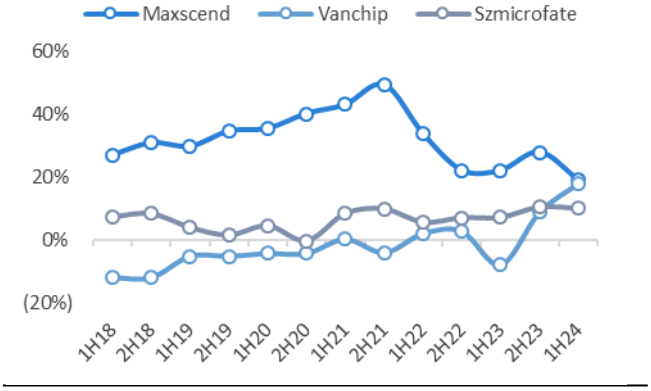
Looking forward, we model Maxscend's net margin to be equal or slightly higher than global incumbent Skyworks and Qorvo thanks to Chinese manufacturers high production to efficiency and shorter distance to the end market. We also think Maxscend's NPM to be consistently higher than its domestic peers Vanchip and Szmicrofate. We think the company's R&D cost shall stay elevated in 2024 with major product development L-PAMiD ready for mass production in 1Q25. We estimate Maxscend's net margin in 2024E/25E to be 16.6%/17.2% respectively.

Figure 108: Net margin comparison with foreign peers



Source: Bloomberg, BOCOM Int'l

Figure 109: Net margin comparison with domestic peers



Source: Bloomberg, BOCOM Int'l

Risk Factors

Risks of Maxscend includes:

1) Weaker than expected demand from downstream smartphone OEMs;

2) Slower than expected R&D progress resulting in a slower ramp up in key products;

3) Domestic or foreign customers change suppliers resulting in a reduce of orders;

4) Higher than expected R&D and/or CAPEX of new product development resulting in lower-than-expected margins;

5) Supply chain localization progress slower than expected as domestic product could miss expectation of product qualification;

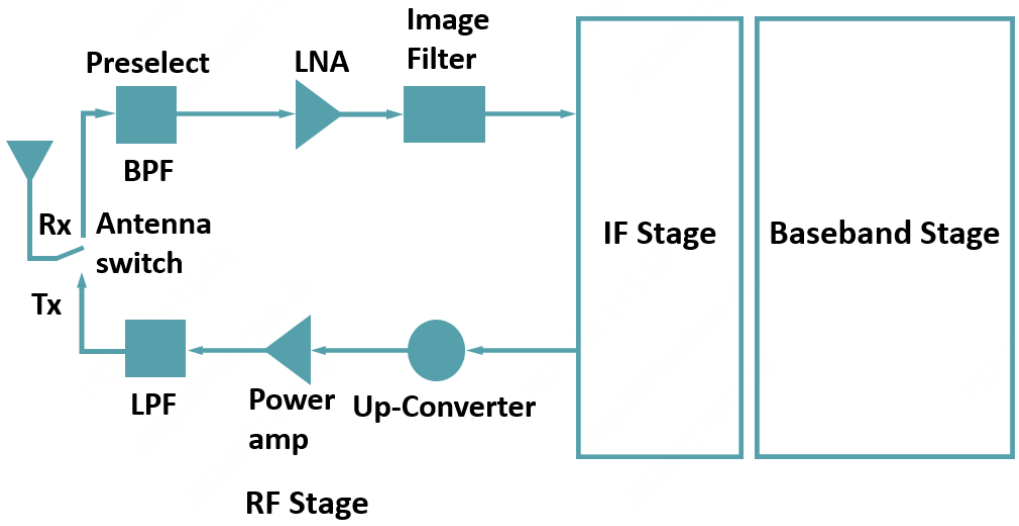
6) Changes in global situations leading to a higher-than-expected cost of production or lower-than-expected end product sales.

Appendix

What is a RF circuit?

Radio frequency front end (RFFE) integrated circuits (ICs) are used widely in wireless communications applications. Its uses span from mobile communications/cellular networks such as 5G to wireless local-area networks (WLAN).

Figure 110: Typical RF Transceiver IC block diagram



Source: Radio Frequency Integrated Circuits, BOCOM Int'l

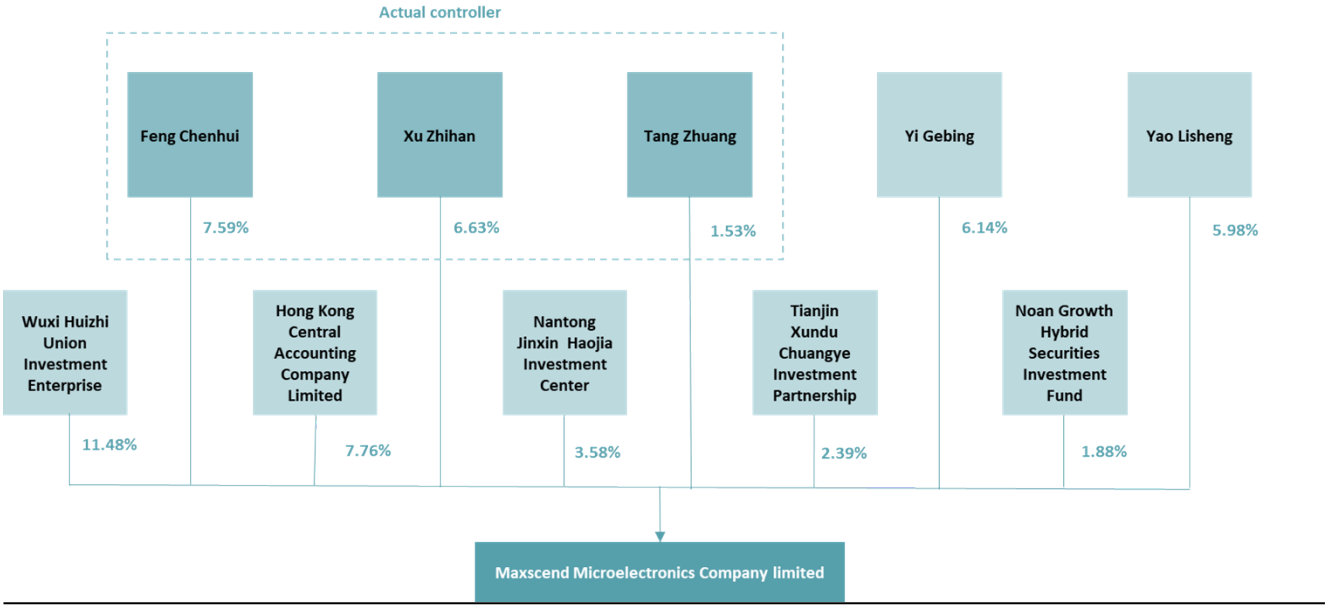
Radio frequency waves serves as the media for wireless communications due to its capability to propagate information in long distances with minimal distortion or noise. In a typical RF transceiver (transmitter + receiver) IC, the role of **switch/duplexer** is to activate or deactivate the antenna with transmitter (Tx) or receiver (Rx) circuitry system. On the transmitting side, the signal to be propagated is converted to the desired frequency by the **up-converter** so that the **power amplifier (PA)** can amplify the signal to prepare for long distance travel. On the receiving side, signal passes through a duplexer/switch and then are filtered to remove undesired signals. The **low-power amplifier (LNA)** will then amplify the filtered signal for better extraction of desired information. Afterwards, the **image filter** will clean the signal by removing unwanted wavelengths and retaining desired signals. The processed signals will then go through baseband processors so that digital information could be extracted.

About Maxscend

Maxscend Technologies is one of the leading research, development, production, and sales company of high-tech radio frequency (RF) integrated circuits in China. Its RF front-end products are mainly employed in mobile intelligent terminal products such as smartphones and other wireless communication devices. The company also provides

Bluetooth microcontroller chips that can be used in electronic devices and smart homes. Starting from a fabless IC design house, the company is under a transition to a fab-lite business model. The company has two production lines, the 6-inch SAW filter production line is in mass production since 2022, and the 12-inch IPD filter production line is in mass production with focus on IPD product since 1Q24. Management of Maxscend includes three of the founders Xu Zhihan, Feng Chenhui and Tang Zhuang, who are veteran engineers working in RFFE industry for decades.

Figure 111: Shareholder structure



Source: Wind, BOCOM Int'l As at 1Q24 end

Figure 112: Management team of Maxscend

Name	Position	Biography
Xu Zhihan	Chairman, General Manager	He is the chairman and general manager of Maxscend, director of Maxscend Technologies (HK) Limited, executive director and manager of Chengdu Maxscend Co., Ltd., executive director and general manager of Jiangsu Xinzhuo Investment Co., Ltd., and director of Maxscend Technology JAPAN Co. He Holds a bachelor's degree in computer science and technology from Tsinghua University, a master's degree in electronic engineering from Santa Clara University in the United States, and an EMBA in Business Administration from China Europe Business School.
Tang Zhuang	Director, Deputy General Manager	He is the director and deputy general manager of Maxscend and chairman of Wuxi Xinzhuo Huguang Semiconductor Co., Ltd. He obtained his bachelor's degree in physics from Peking University, master's degree and PhD in electronic engineering from the University of Illinois at Urbana-Champaign.
Feng Chenhui	Director, Deputy General Manager	He is the director and deputy general manager of Maxscend, director of Beijing CH-Auto Technology Co., Ltd., director of Maxscend Technology Singapore Pte. Ltd., and director of Wuxi Xinzhuo Huguang Semiconductor Co., Ltd He holds a bachelor's and a master's degree in electronic engineering from Tsinghua University.
Yao Lisheng	Director	He is the director of Maxscend and executive director and general manager of Feitu Venture Investment (Beijing) Co., Ltd. and Spark Venture Capital (Beijing) Co., Ltd.

Source: Maxscend, BOCOM Int'l

Figure 113: Company milestones

Date	Milestones
2006	Maxscend Cayman and Maxscend Cayman was established.
2013	**LNA: Global satellite positioning LNA mass production.** Started supplying RF front-end chip products to Samsung (005930 KS).
2014	**Switch**: Communication mobile conduction switch and WiFi switch mass production.
2015	**Switch**: Antenna tuning switch mass production. **LNA**: Mass production of mobile communication signals and telecommunication signals. Single chip integrated LNA and Switch mass production。
2017	**LNA**: FM signal LNA mass production.
2020	**Start the construction of Xinzhuo project.**
2021	**Module**: Start testing L-PAMiF for 5G NR band. WiFi6 compliant connectivity module products mass production.
2022	**Start to shift from Fabless to Fab-Lite** **Filter:** 6-inch filter production line into mass production, completion of SAW filter process R&D platform construction, 12-inch IPD filter into small batch production **Module:** Development in DiFEM, L-DiFEM, GPS, LFEM and LNA Bank module
2023	**Filter: Max-SAW mass production, filter production line capacity steadily climbing.** **Module: L-FEMiD in research and development process**
2024	**Filter: IPD filter starts in production under 12-inch production line** **Module: L-PAMiF in ramping up in production, L-FEMiD in qualification process, L-PAMiD module in research process**

Source: Maxscend, BOCOM Int'l

Figure 114: Maxscend (300782 CH) TP & Rating

Source: FactSet, BOCOM Int'l estimates

Financial Statements

Income statement (RMB m)

Y/E 31 Dec	2022	2023	2024E	2025E	2026E
Revenue	3,677	4,378	5,099	6,134	7,012
COGS	(1,732)	(2,345)	(2,987)	(3,670)	(4,107)
Gross profit	**1,946**	**2,034**	**2,112**	**2,465**	**2,905**
SG&A	(139)	(201)	(222)	(202)	(215)
R&D	(449)	(629)	(1,032)	(1,168)	(1,260)
Other operating income, net	(6)	(11)	(12)	(14)	(17)
Operating profit	**1,351**	**1,192**	**847**	**1,080**	**1,414**
Net finance expenses	35	44	4	12	3
Other non-op. income, net	(296)	(65)	(6)	3	3
Pre-tax profit	**1,089**	**1,171**	**845**	**1,096**	**1,420**
Tax	(11)	(52)	4	(36)	(50)
Non-controlling interests	(9)	3	(0)	(3)	(4)
Net profit	**1,069**	**1,122**	**849**	**1,056**	**1,365**
Net profit for EPS calculation	1,069	1,122	849	1,056	1,365

Balance sheet (RMB m)

As of 31 Dec	2022	2023	2024E	2025E	2026E
Cash & cash equiv	1,214	720	462	750	1,650
Acc & bills receivable	400	518	603	726	830
Inventories	1,720	1,493	1,901	2,336	2,615
Other current assets	254	538	579	638	688
Total current assets	**3,588**	**3,269**	**3,545**	**4,450**	**5,782**
PPE	4,539	5,602	6,293	6,557	6,655
Intangible assets	123	122	109	98	88
Long-term income receivables	221	222	178	142	114
Other non-current assets	1,033	1,743	1,743	1,743	1,743
Total non-current assets	**5,915**	**7,689**	**8,322**	**8,540**	**8,600**
Total assets	**9,504**	**10,958**	**11,868**	**12,989**	**14,382**
Short-term loans	0	0	0	0	0
Trade and other payables	476	635	809	994	1,112
Other current liabilities	245	246	246	246	246
Total current liabilities	**721**	**881**	**1,054**	**1,239**	**1,358**
Long-term loans	0	0	0	0	0
Other non-current liabilities	98	274	274	274	274
Total non-current liabilities	**98**	**274**	**274**	**274**	**274**
Total liabilities	**819**	**1,154**	**1,328**	**1,513**	**1,632**
Share capital	534	534	534	534	534
Reserves & other capital items	8,148	9,269	10,005	10,942	12,216
Shareholders' equity	**8,682**	**9,803**	**10,539**	**11,476**	**12,750**
Non-controlling interests	3	0	0	0	0
Total equity	**8,685**	**9,803**	**10,539**	**11,476**	**12,751**

Source: Company data, BOCOM Int'l estimates

Cash flow (RMB m)

Y/E 31 Dec	2022	2023	2024E	2025E	2026E
Net profit	1,078	1,119	849	1,059	1,370
Depreciation & amortisation	95	211	410	528	579
Change in working capital	(255)	237	(320)	(372)	(264)
Interest inc/exp adjustment	(32)	7	7	7	7
Other operating cashflow	56	320	(41)	(59)	(50)
Cash flow from operation	**942**	**1,894**	**905**	**1,163**	**1,641**
Capex	(1,711)	(2,010)	(1,088)	(781)	(667)
Investment	29	(1)	44	36	28
Other investing cashflow	63	(282)	0	0	0
Cash flow from investing	**(1,619)**	**(2,292)**	**(1,044)**	**(745)**	**(639)**
Net chg in interest-bearing debt	0	0	0	0	0
Net change in equity	6	18	0	0	0
Dividends paid	(234)	(91)	(120)	(129)	(102)
Other financing cashflow	(5)	(21)	0	0	0
Cash flow from financing	**(233)**	**(94)**	**(120)**	**(129)**	**(102)**
Exchange gain/loss	104	(2)	0	0	0
Cash & cash equiv. at year start	**2,020**	**1,214**	**720**	**462**	**750**
Cash & cash equiv. at year end	**1,214**	**720**	**462**	**750**	**1,650**

Financial ratio

Y/E 31 Dec	2022	2023	2024E	2025E	2026E
Per share data (RMB)					
Core EPS	2.004	2.103	1.590	1.978	2.557
BVPS	16.266	18.365	19.737	21.492	23.878
Margin analysis (%)					
Gross margin	52.9	46.4	41.4	40.2	41.4
EBITDA margin	30.7	29.5	24.6	25.6	27.7
EBIT margin	28.1	24.6	16.6	17.0	19.4
Net margin	29.1	25.6	16.6	17.2	19.5
Profitability analysis (%)					
ROA	11.9	11.0	7.4	8.5	10.0
ROE	13.1	12.1	8.3	9.6	11.3
ROIC	15.4	11.6	8.1	9.1	10.7
Others					
Net debt to equity ratio (%)	Net Cash	Net Cash	Net Cash	Net Cash	Net Cash
Current ratio (x)	5.0	3.7	3.4	3.6	4.3
Inventory turnover (days)	336.7	250.0	207.4	210.7	220.0
Acc receivable turnover (days)	48.3	38.3	40.1	39.5	40.5
Acc payable turnover (days)	89.8	86.5	88.2	89.6	93.6

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Analyst Stock Rating:	Analyst Industry Views:
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