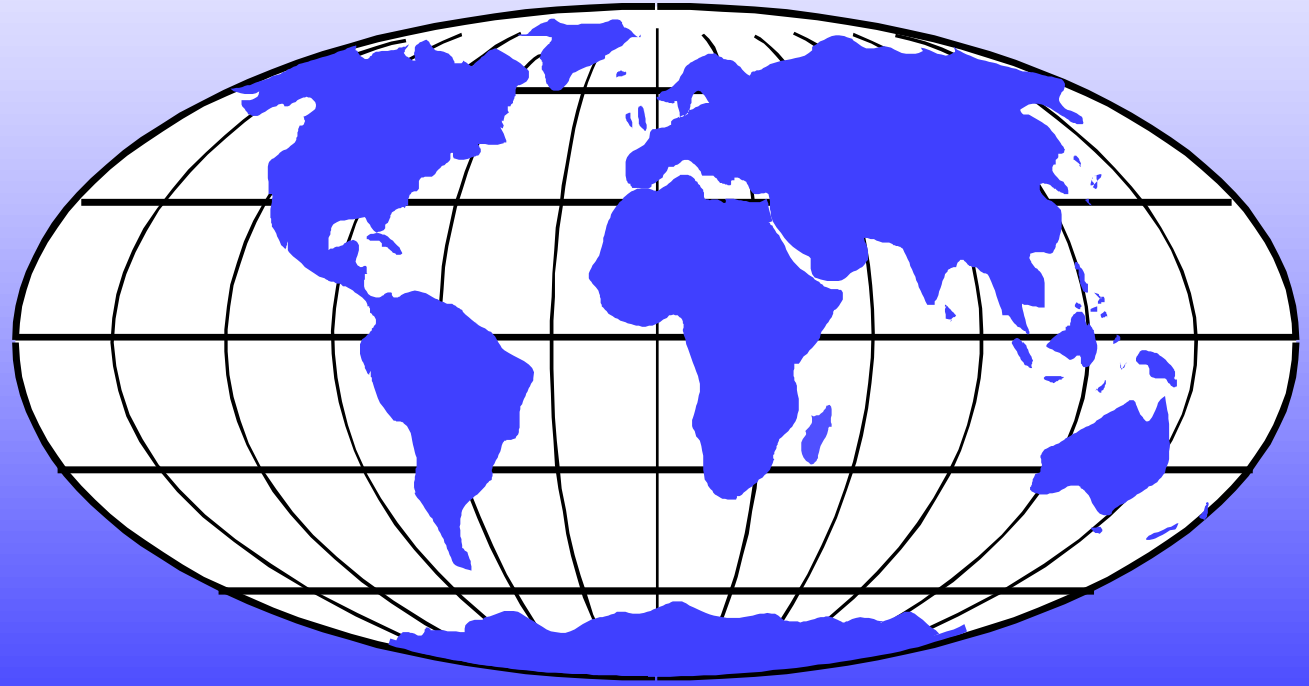
KEY ISSUES FOR GSA WITHIN SEMICONDUCTOR INDUSTRY AND AI

SEPTEMBER 27, 2022



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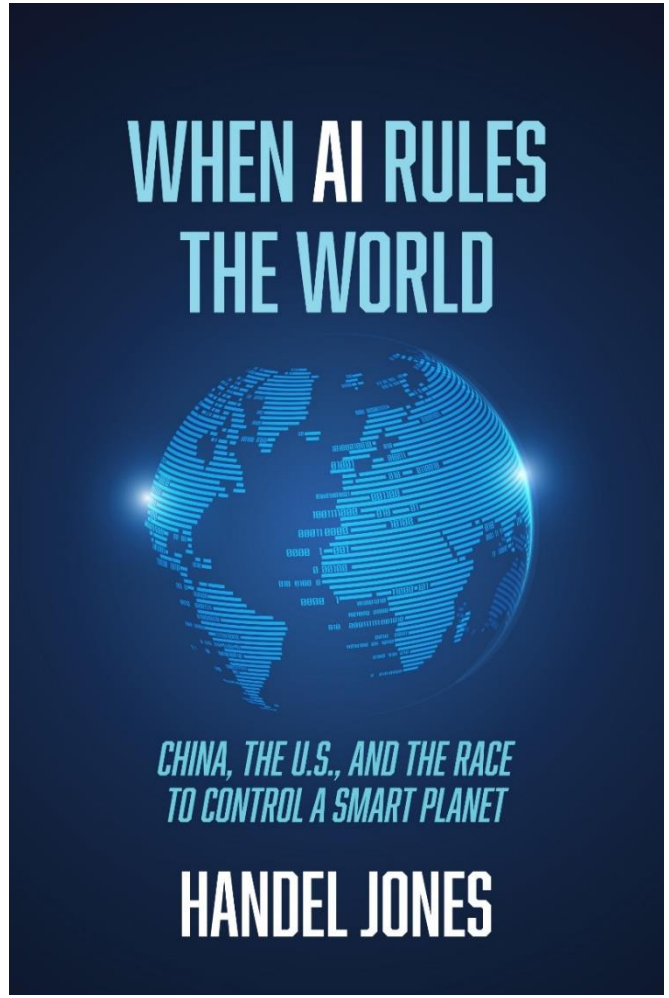
1 IBS' BACKGROUND

- IBS has been in business for >33 years
- IBS is active in providing market and strategic support to many companies globally in semiconductor industry

  Many leaders in semiconductor and electronics industries are clients of IBS and provide inputs on key trends in these industries
- Founder published three books on China regarding key factors in electronics and semiconductors in China
- New fourth book on China called *When AI Rules the World: China, the U.S., and the Race to Control a Smart Planet* (Simon & Schuster). Available from Amazon on October 11, 2022

  This book focuses on AI and provides visibility into positions of U.S. and China in future
- Hope you enjoy reading *When AI Rules the World*



IBS IS ACTIVE IN BOTH LONG-TERM AND SHORT-TERM ACTIVITIES IN GLOBAL SEMICONDUCTOR INDUSTRY AND IN MONITORING SLOWING IN DEMAND CLOSELY

2 TOP-LEVEL STRATEGIC ISSUES THAT IMPACT SEMICONDUCTOR MARKET

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QUARTERLY GDP GROWTH RATES OF U.S. AND CHINA

Growth rate (%)	2020				2021				2022	
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
QoQ										
U.S.[1]	(5.1)	(31.2)	33.8	4.5	6.3	6.7	2.3	6.9	(1.6)	(0.6)
China[2]	(10.3)	11.7	3.3	2.4	0.6	1.5	0.4	1.4	1.4	(2.6)
YoY										
U.S.[1]	0.6	(9.1)	(2.9)	(2.3)	0.5	12.2	4.9	5.5	3.5	1.7
China[2]	(6.9)	3.1	4.8	6.4	18.3	7.9	4.9	4.0	4.8	0.4

[1] *Source: U.S. Bureau of Commerce, Bureau of Economic Analysis.*

[2] *Source: National Bureau of Statistics of China.*

- ***GDP growth rate is slowing on global basis***

  U.S. continues to be key factor in global GDP followed by China

- ***Inflation impacts consumer consumption***
  - Inflation rate of U.S. was 8.3% in August 2022
  - Federal Reserve continues to increase interest rates in attempt to bring inflation rate down to 2%

    Federal funds rate is currently at 3.25% and is expected to peak at 4.6% in 2023
  - U.S. government is providing more liquidity

2 TOP-LEVEL STRATEGIC ISSUES THAT IMPACT SEMICONDUCTOR MARKET (CONTINUED)

- ***Energy issues in E.U. continue to be problem***
  - Germany has major challenges and allocating €65.0 billion ($64.9 billion) to help alleviate increasing energy cost
  - France is conducting maintenance on nuclear power stations

    Capping electricity price increase at 15% in 2023
  - China is expanding supply of oil and natural gas, which increases energy prices in E.U.
  - Increase in energy costs may reduce consumer buying power for electronics products and semiconductors
- ***Attempts to control COVID-19 are impacting consumer spending in China***
  - Effective shutdown of Chengdu (China)

    Limitations in Shenzhen (China)

    Shanghai (China) and Beijing (China) are facing some restrictions
  - Zero-COVID-19 policy will continue until government announces new policy after 20th National Congress meeting on October 16, 2022

    Key factor for ongoing COVID-19 cases in China is ineffectiveness of Chinese vaccines

    China continues to represent approximately 50% of semiconductor market

2 TOP-LEVEL STRATEGIC ISSUES THAT IMPACT SEMICONDUCTOR MARKET (CONTINUED)

IBS

TRADE BETWEEN U.S. AND CHINA

	Trade of goods and services ($B)			
	2020	2021	H1/2022	Comments
Imports by U.S. from China	448.9	526.8	310.6	Involve wide range of products China is slowing its exports to U.S. in H2/2022, but U.S. will likely have record imports from China in 2022
Exports by U.S. to China	166.3	192.0	97.0	Exports by U.S. include oil and farm products In addition to U.S., China has many other sources for supply of oil and farm products Semiconductors are key high-technology products of U.S. and represent key exports to China Aircrafts were significant in past, and Airbus is benefiting from Boeing's ongoing supply chain issues
Balance of trade	-282.6	-334.8	-213.6	U.S. has large trade deficit with China, and this will likely continue in 2023 and 2024 Manufacturing expertise in China continues to improve

- ***Sales restrictions on semiconductor technology to China are increasing***
  - U.S. continues to be large market for Chinese goods and to have very strong reliance on China for many different goods

    Finding alternative sources to supply of goods and services from China will be difficult and will contribute to higher inflation in U.S.
  - However, U.S. government is increasing restrictions on semiconductors sold to China

2 TOP-LEVEL STRATEGIC ISSUES THAT IMPACT SEMICONDUCTOR MARKET (CONTINUED)

- U.S. government has following limitations on China:
  - ***EDA tools for GAA:*** Not effective unless EDA companies stop providing PDKs to TSMC and Samsung

    This restriction may potentially extend to all GAA products shipped to China
  - ***H100 and other AI processors:*** Major impact on AI activities in China

    No alternative solutions in next few years
  - ***EUV lithography scanners:*** May extend to products that use EUV such as DRAM
  - ***<14nm wafer processing equipment:*** May apply to most wafer processing equipment

    Many wafer processing equipment are used for wide range of technologies such as DUV scanners
- These government restrictions will have major impact on digitization of China and adoption of big data, which affects semiconductor consumption
- China will take retaliatory steps against U.S., with multiple options

  Most likely actions are increase in prices and limitations on shipment of certain items to U.S.
- U.S. government will take additional actions against China, which may increase trade tension

SEMICONDUCTOR INDUSTRY IS GOING THROUGH CHALLENGING PHASE, BUT THIS HAS OCCURRED MANY TIMES IN PAST

3 SEMICONDUCTOR MARKET PERSPECTIVE

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SCENARIOS FOR SEMICONDUCTOR MARKET IN 2022 TO 2023

	2021		2022						2023						Growth rates for scenarios in 2023 over 2022 (%)		
	TOTAL ($B)	Growth (%)	Q1	Q2	Q3	Q4	TOTAL ($B)	Growth (%)	Q1	Q2	Q3	Q4	TOTAL ($B)	Growth (%)	Optimistic	Realistic	Pessimistic
Actual	**552.6**	**23.9**	**156.2**	**155.7**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**	**--**
Optimistic	--	--	--	--	152.5	149.6	614.0	11.1	148.3	147.2	155.1	155.0	605.6	(1.4)	(1.4)	0.1	2.3
Realistic	--	--	--	--	150.4	142.9	605.2	9.5	141.1	143.5	149.7	150.2	584.5	(3.4)	(4.8)	(3.4)	(1.2)
Pessimistic	--	--	--	--	144.6	135.2	591.7	7.1	134.1	138.7	142.5	145.7	561.0	(5.2)	(8.6)	(7.3)	(5.2)

- Semiconductor market in 2022
  - Optimistic: 11.1%
  - Realistic: 9.5%
  - Pessimistic: 7.1%
- Semiconductor market in 2023
  - Optimistic: 0.1%
  - Realistic: -3.4%
  - Pessimistic: -7.3%

3 SEMICONDUCTOR MARKET PERSPECTIVE (CONTINUED)

- Many factors drive growth of semiconductor market, which compensate for some negative trends
  - ***5G smartphones:*** Increasing semiconductor value per smartphone

    Smartphones represent approximately 36% of semiconductor market

SEMICONDUCTOR CONSUMPTION PER SMARTPHONE

	2022	2026	2030
5G Smartphone (MU)	**701**	**1,239**	**1,824**
Semiconductor/smartphone ($)	**182.40**	**195.12**	**226.79**
Smartphone semiconductor ($M)	**127,917**	**241,707**	**413,659**
Percent total smartphone semi. (%)	57.17	74.05	84.00
≤4G Smartphone (MU)	**746**	**624**	**519**
Semiconductor/smartphone ($)	**128.44**	**135.81**	**151.76**
Smartphone semiconductor ($M)	**95,840**	**84,706**	**78,779**
Percent total smartphone semi. (%)	42.83	25.95	16.00
TOTAL Smartphone (MU)	**1,447**	**1,862**	**2,343**
Smartphone semiconductor ($M)	**223,757**	**326,413**	**492,438**

3 SEMICONDUCTOR MARKET PERSPECTIVE (CONTINUED)

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PC MARKET

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Notebook (MU)	**160.8**	**163.5**	**165.7**	**180.2**	**227.8**	**265.4**	**242.3**	**238.9**	**249.7**	**265.2**
Growth rate (%)	NA	1.7	1.3	8.8	26.4	16.5	(8.7)	(1.4)	4.5	6.2
Desktop (MU)	**82.3**	**81.1**	**79.2**	**77.0**	**62.3**	**56.2**	**52.7**	**53.3**	**55.2**	**58.1**
Growth rate (%)	NA	(1.5)	(2.3)	(2.8)	(19.1)	(9.8)	(6.2)	1.1	3.7	5.1
TOTAL (MU)	**243.1**	**244.6**	**244.9**	**257.2**	**290.1**	**321.6**	**295.0**	**292.2**	**304.9**	**323.2**
Growth rate (%)	NA	0.6	0.1	5.0	12.8	10.9	(8.3)	(1.0)	4.4	6.0

- ***PCs:*** Semiconductor consumption per PC has some growth in 2023
- ***Data centers:*** Strong growth in consumption of semiconductors

  AMD projects revenue growth of 60% in 2022

  Some slowing in Q3/2022 and further slowing in Q4/2022

  Project recovery in Q3/2023 or Q4/2023
- ***Automotive:*** Increasing semiconductor consumption per vehicle, and potential for selling higher number of vehicles

3 SEMICONDUCTOR MARKET PERSPECTIVE (CONTINUED)

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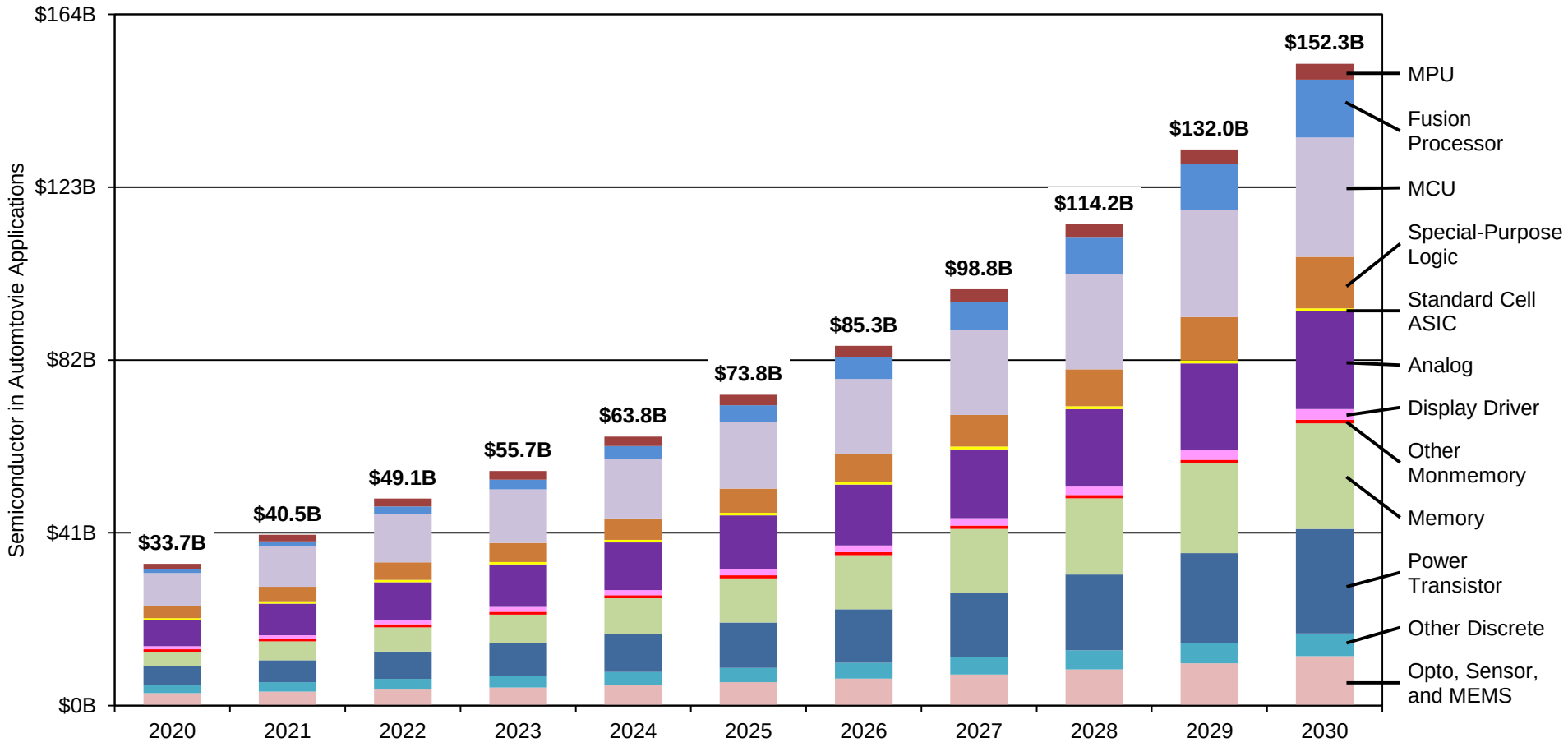
AUTOMOTIVE SEMICONDUCTOR MARKET BY PRODUCT



Automotive semiconductor market will grow in 2023

Key areas of growth are digitization of cockpit and adoption of smartphone interface

3 SEMICONDUCTOR MARKET PERSPECTIVE (CONTINUED)

IBS

PRODUCTION VOLUME OF EVs AND ICE VEHICLES

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
EVs (KU)	**3,077**	**6,196**	**8,493**	**10,061**	**12,981**	**16,205**	**20,090**	**24,575**	**29,972**	**36,206**	**40,970**
Growth rate (%)	NA	101.34	37.07	18.46	29.02	24.84	23.98	22.32	21.96	20.80	13.16
Percent total (%)	3.96	7.73	9.98	11.46	14.30	17.34	20.99	25.17	30.16	35.86	40.01
ICE vehicles (KU)	**74,634**	**73,959**	**76,608**	**77,729**	**77,794**	**77,248**	**75,624**	**73,062**	**69,404**	**64,759**	**61,429**
Growth rate (%)	NA	(0.90)	3.58	1.46	0.08	(0.70)	(2.10)	(3.39)	(5.01)	(6.69)	(5.14)
Percent total (%)	96.04	92.27	90.02	88.54	85.70	82.66	79.01	74.83	69.84	64.14	59.99
TOTAL (KU)	**77,712**	**80,155**	**85,101**	**87,790**	**90,775**	**93,452**	**95,714**	**97,638**	**99,376**	**100,966**	**102,400**
Growth rate (%)	NA	3.14	6.17	3.16	3.40	2.95	2.42	2.01	1.78	1.60	1.42

Note:
Standard hybrids are under ICE vehicles. Plug-in hybrids are under EVs.

ADAS will evolve from L3 to L5 in next few years

Vehicle electrification is area of highest growth

Chinese government has target for NEVs to represent 20% of automobile sales in China by 2025 (mainly EVs)

Shortage of key components is limiting EV growth and is major opportunity for semiconductor industry

3 SEMICONDUCTOR MARKET PERSPECTIVE (CONTINUED)

IBS

- ***SiC:*** Large market opportunity for SiC products

SiC MARKET

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Solar ($M)	**134**	**157**	**196**	**237**	**283**	**326**	**376**	**433**	**498**	**569**	**649**	**735**	**823**
Growth (%)	NA	17.16	24.84	20.92	19.27	15.32	15.44	15.16	14.82	14.41	13.96	13.25	11.98
Percent total (%)	34.10	24.12	22.25	16.01	13.52	11.15	9.24	7.70	6.46	5.47	4.67	4.03	3.48
Electric vehicles ($M)	**148**	**342**	**498**	**989**	**1,442**	**2,071**	**2,936**	**4,099**	**5,637**	**7,636**	**10,169**	**13,326**	**17,291**
Growth (%)	NA	131.08	45.61	98.60	45.76	43.68	41.74	39.63	37.51	35.46	33.18	31.04	29.76
Percent total (%)	37.66	52.53	56.53	66.82	68.96	70.82	72.12	72.88	73.23	73.33	73.24	73.11	73.10
Industrial ($M)	**72**	**80**	**97**	**138**	**199**	**283**	**396**	**548**	**745**	**997**	**1,309**	**1,685**	**2,113**
Growth (%)	NA	11.11	21.25	42.27	44.12	42.20	40.16	38.22	36.00	33.81	31.24	28.76	25.43
Percent total (%)	18.32	12.29	11.01	9.32	9.51	9.67	9.74	9.74	9.68	9.58	9.42	9.24	8.93
Others ($M)	**39**	**72**	**90**	**116**	**167**	**245**	**362**	**544**	**817**	**1,211**	**1,759**	**2,481**	**3,428**
Growth (%)	NA	84.62	25.00	28.89	44.27	46.13	48.05	50.26	50.24	48.17	45.23	41.07	38.16
Percent total (%)	9.92	11.06	10.22	7.84	8.01	8.36	8.89	9.67	10.62	11.63	12.67	13.61	14.49
TOTAL SiC ($M)	**393**	**651**	**881**	**1,480**	**2,090**	**2,925**	**4,071**	**5,625**	**7,697**	**10,413**	**13,885**	**18,227**	**23,656**
Growth (%)	NA	65.65	35.33	67.99	41.25	39.90	39.18	38.18	36.85	35.29	33.35	31.26	29.79

3 SEMICONDUCTOR MARKET PERSPECTIVE (CONTINUED)

IBS

- ***Industrial:*** Ongoing steady growth

  Synergistic with automotive

  However, industrial applications represent small percentage of semiconductor market

- ***China provides stimulus package to improve consumer spending***

  - This stimulus will have positive impact on semiconductor consumption in 2023
  - Strong emphasis in China on building up its semiconductor supply chains
  - China will continue to need access to advanced feature products

LONGER-TERM PERSPECTIVE FOR SEMICONDUCTOR MARKET IS POSITIVE

SEMICONDUCTOR MARKET WILL BE >$1.0 TRILLION IN 2030

4 PERCENT OF SUPPLY MEETING DEMAND, AS OF SEPTEMBER 2022

IBS

(%)	2022					2023								
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
MPU	100.8	102.0	103.5	103.9	104.2	104.4	104.5	104.4	104.2	103.6	103.0	102.4	101.6	100.9
MCU	88.3	88.8	89.2	89.9	90.7	91.9	93.3	95.1	97.0	98.7	99.6	100.4	101.0	101.7
4G/5G chipset	101.9	102.8	103.1	103.2	103.0	102.8	102.6	102.4	102.1	101.8	101.5	101.2	100.8	100.5
GPU	102.1	103.5	104.0	104.4	104.2	104.0	103.8	103.6	103.1	102.7	102.0	101.3	100.5	100.1
Wi-Fi and other RF	97.6	98.6	99.3	99.7	100.1	100.3	100.5	100.7	100.8	100.9	100.9	100.8	100.7	100.6
Precision analog	99.9	100.1	100.2	100.4	100.6	100.8	101.0	101.2	101.3	101.4	101.5	101.4	101.3	101.2
Power management	96.7	97.5	98.2	98.7	99.2	99.6	99.9	100.2	100.4	100.7	101.2	101.4	101.6	101.8
BMS	94.3	95.3	96.4	97.3	97.8	98.3	98.7	99.1	99.5	99.9	100.1	100.2	100.3	100.5
DRAM	101.0	102.2	102.9	103.6	104.1	104.5	104.9	104.5	104.1	103.5	102.9	102.2	101.5	100.8
NAND	100.9	102.3	103.2	104.1	104.9	105.5	105.8	105.1	104.2	103.7	103.2	102.7	101.1	101.6
Power transistor	93.4	93.6	93.9	94.5	95.2	95.8	96.4	97.0	97.6	98.2	98.6	99.0	99.3	99.7
Image sensor	100.4	101.2	101.6	101.9	102.3	102.5	102.7	102.8	102.7	102.6	102.5	102.3	102.1	101.8
ISP	98.5	99.2	99.7	100.0	100.2	100.4	100.6	100.9	101.5	102.2	102.9	102.8	102.5	102.2

PROJECTING TURNAROUND IN Q3/2023

5 WHY WILL AI RULE WORLD?

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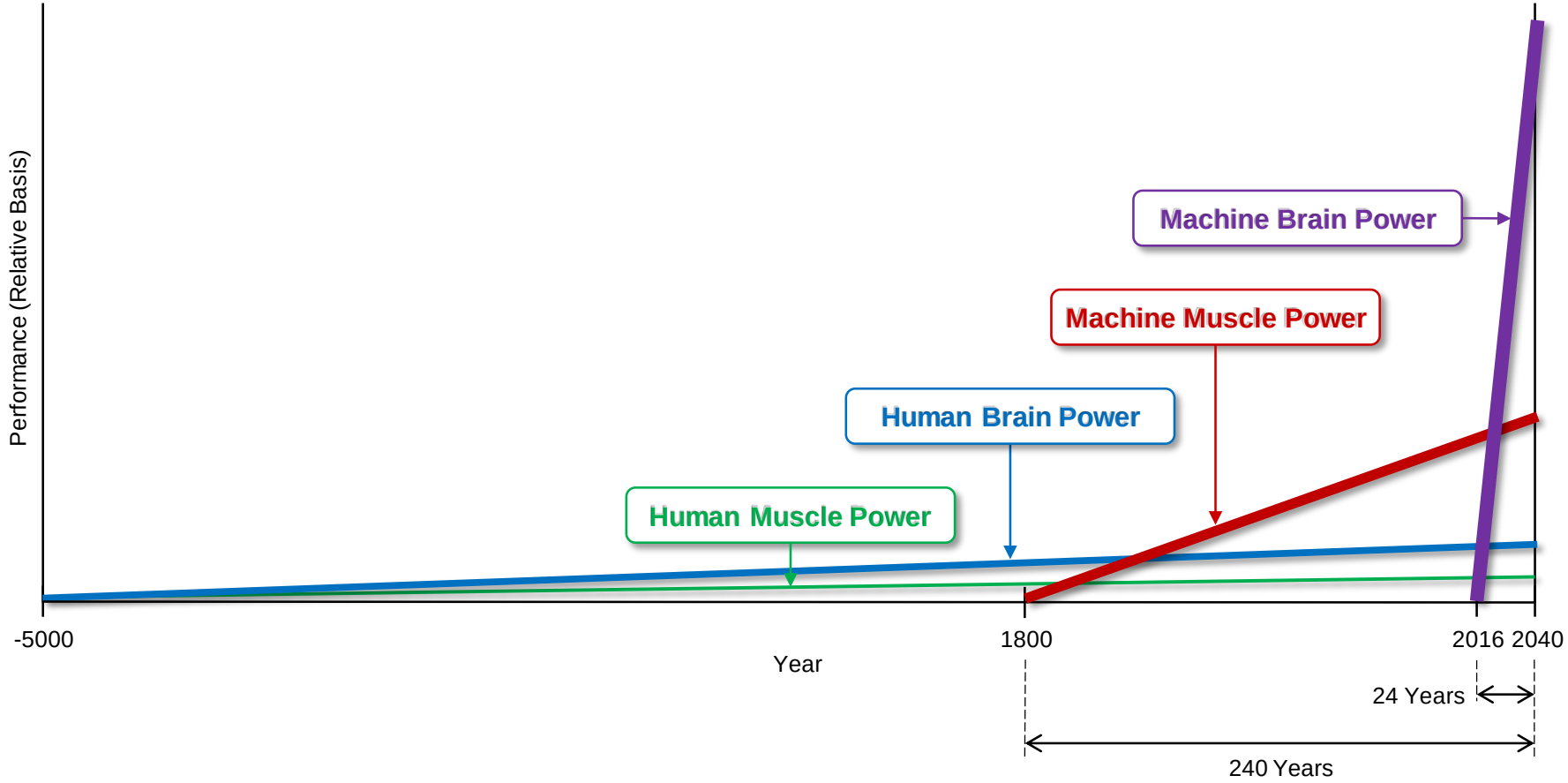
POWER OF MACHINE AND HUMAN BRAIN WITH AI



INCREASING HUMAN BRAIN POWER RATHER THAN MUSCLE POWER WILL HAVE GREATER IMPACT ON SOCIETY

IMPACT OF MACHINE BRAIN POWER WILL OCCUR IN NEXT 20 YEARS WHILE MACHINE MUSCLE POWER HAS OCCURRED >200 YEARS

6 WHAT ARE MAJOR FACTORS RELATED TO AI?

IBS

- ***Big increase in semiconductor content because of AI***

  Examples include smartphones, autonomous vehicles, data centers

- ***Emergence of virtual digital twin***
  - People will have large amount of data on superphone

    Computing power of virtual digital twin will be much more powerful than human brain
  - Virtual digital twin will dramatically strengthen analysis and decision-making capabilities of people

    However, virtual digital twin will not have emotion
  - Individual's data in virtual digital twin may continue to survive after person's death
- ***VR addiction in 2030***
  - VR allows people to live in virtual world and without need for real goods
  - This may result in major changes in lifestyle of many people
  - May also allow control over minds of people

6 WHAT ARE MAJOR FACTORS RELATED TO AI? (CONTINUED)

IBS

- ***Large reduction in people required for manufacturing and services***
  - Smart robots will dominate in manufacturing
  - Emergence of new service industries may improve quality of life
  - However, digital health will become very large market, with expectation of longer useful lives for many people
- ***Early adopter in many areas of AI in China***
  - China has top-down and highly entrepreneurial approaches
  - In 6G, China will be three to four years ahead of U.S. and Europe
  - 3D facial recognition technology supports better efficiency in many transactions
  - China is making large investments in automated factories with smart robots
  - Progress in smart drones, hypersonic missiles, and space exploration is rapid in China
  - Autonomous transportation is another area of strong emphasis in China

    Plans for autonomous transportation of goods and people in 2035

    Developing trains at 600kmph

6 WHAT ARE MAJOR FACTORS RELATED TO AI? (CONTINUED)

IBS

- China will have large export of EVs

  Main reasons are leadership in battery technology and large manufacturing capacity

  Also focusing on L3 ADAS in short term and L5 in longer term

- As early AI adopter, China will have many missteps

  Other countries, however, should not underestimate China's progress in many areas of technology

- ***Key requirement for China is access to advanced semiconductors***

- How semiconductor industry ecosystem will evolve involves many factors

- U.S. and China will likely have additional areas of conflict in future

U.S. NEEDS STRATEGIES FOR ACCELERATING AI ADOPTION AS WELL AS TRYING TO SLOW DOWN CHINA

U.S. IS LEADER IN INNOVATION PROVIDED APPROPRIATE OPERATING STRUCTURE IS IN PLACE

SEMICONDUCTORS REPRESENT KEY ENABLING CAPABILITY FOR AI AND SOCIETY