Market and Packaging Trends in Mobile Devices

October 9, 2013 – MEPTEC

Distribution Deck

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Market Intelligence

Discussion Outline

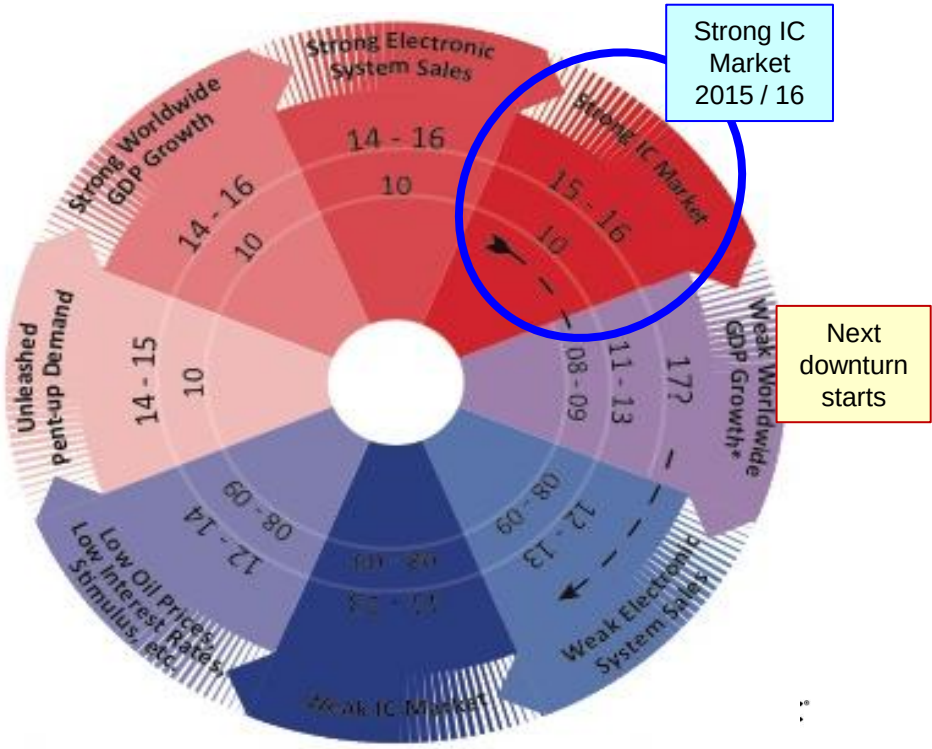
- IC Market and GDP
- Why focus on mobile devices
- SP and T unit forecast by price segment
  - SP OEM revenues by price segment
- Significance of China SP OEMs for Mobile IC growth
  - Emerging regions versus Developed regions
  - Low cost SP examples and “white-box” SP and T OEMs
- 2013 – SP and T OEM and MP MS
  - Mobile OEM profitability landscape
  - China OEMs -- Hyper-growth at present (~50% for export)
- Phone BOM by SP Price segments and key ICs
- Packaging OSAT revenue for SP Mobile processors
  - MP total packaging (SAT) revenues will likely stay flat
  - 2013 packaging SAT for SP Non-processor ICs
- 2016 Landscape Scenarios for SPs and Ts
- Market and Packaging Trend Overview

Positive IC Growth to Parallel Global GDP – 2014-16

- 2010-2013 correlation between global GDP and IC market growth has been exceptionally high – 0.94 correlation coefficient – for two reasons:
  - IC vendors in key segments have consolidated / high concentration
  - IC revenues are increasingly driven by "consumer" sector
- In the 2014-2017 period such high correlation will likely continue (IC Insights)
  - A strong IC market in 2015 and 2016 -- pent-up demand and strong systems sales
    - Before the inevitable next downturn starting in 2017
    - Warning: Gartner currently forecasts next downturn in 2015 – possible, not likely
- Closely monitor global / regional GDP trends !!

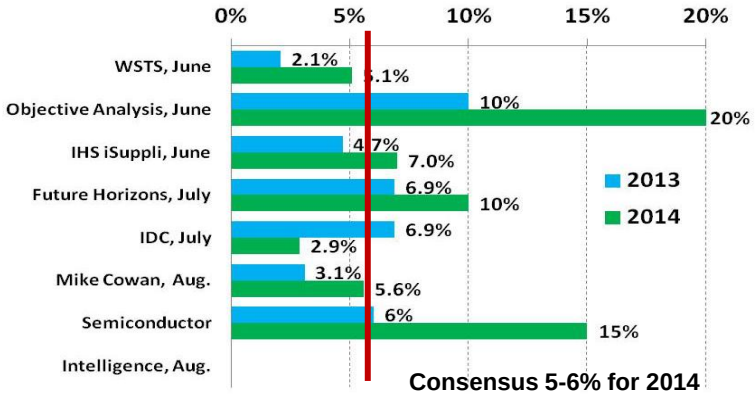
IC Insights Forecast (Sept. 2013)

- 2013 IC revenue 6% (4% without DRAM – due to DRAM ASP increase in 2013)
  IC Units 4%
- 2014 IC revenue 8%
  IC units 5%
- 2015 IC revenue 10%
  IC units 7%
- 2016 IC revenue 13%
  IC units 8%
- 2017 IC revenues <1%> (down cycle)
  IC units 2%



Other Semiconductor Rev Forecasts 2013 / 2014

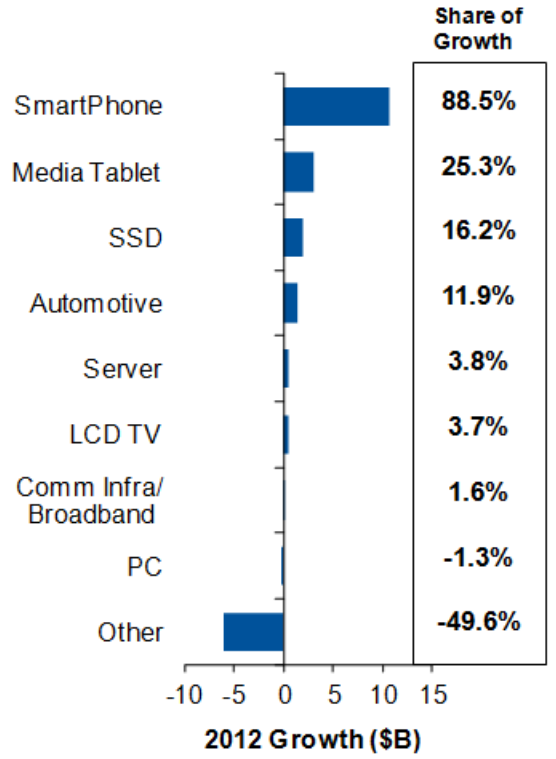
(only IDC (July) forecasts 2014 < 2013)



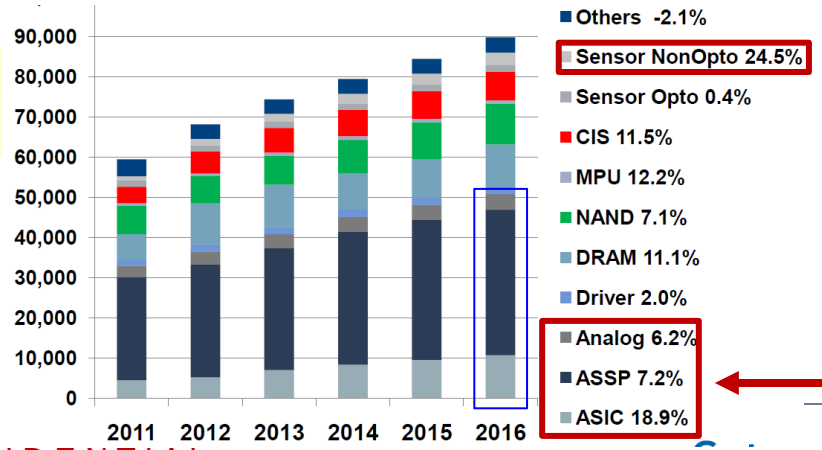
Why Mobile Device Focus?

- Convergence markets are driving semiconductor demands
  - Especially in SPs and Ts
  - 466M Ts by 2016 ➔ ~50% of total 0.95B PC units
  - 2B+ SPs by 2017 (1B+ in 2013) ➔ ~86% penetration of 2.35B phones
- Convergent devices require advanced ATE to support the complex SoC test
  - An increasing need for turnkey packaging
- In 2013 IC Insights has (finally) reclassified T and SP SoC processors into MPUs
  - $65B for MPUs in 2013 **(SP 26%, T 5%)** and $104B in 2017 **(38% SP, 6% T)**
  - 2012-17 revenue CAGR for Ts 22% and SPs 24% (for all other PC, server and embedded MPUs only 7%) ➔ SP and T IC growing faster than total ICs
- Mobile processors (MP) account for ~35% of total IC value in SPs
  - XCVR are added since always the same vendors as BB; in Hi-end PCs also
  - MPs are of high importance to OSAT, IC and OEM vendors

Contribution to 2012 Growth
(Gartner)



ICs in SPs and Ts (M$)
2011 – 2016 Gartner



SP and T Unit Forecast by Price Segment

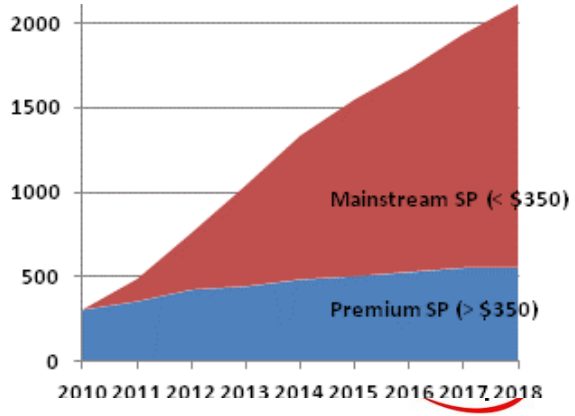
SP Units (M) - Sept 2013 Model (Primary Source for China – Deutsche Bank, Nomura, IC Insights, Gartner, IDC, Credit Suisse)

SP UNITS	2010	2011	2012	2013	2014	2015	2016	2017	2018	2013-2017 CAGR	2013-2015 CAGR
Hi-end SP (> $350)	300	350	420	440	480	500	525	550	550	6%	7%
Mid-end SP (< $350 - >$150)	0	102	186	280	385	465	516	590	650	20%	29%
Lo-end SP (< $150 by 2015 < $100)	0	30	150	320	470	585	690	800	916	26%	35%
Total SP Units (M)	**300**	**482**	**756**	**1040**	**1335**	**1550**	**1731**	**1940**	**2116**	17%	22%
Conservative Forecasts (Credit Suisse, IDC, other)	299	473	716	976	1219	1425	1577	1737	1995	**16%**	**21%**
				QTI does not count 2.75G (Edge) SPs + WB lack of visibility							
Feature (FP) - CS	1354	1379	1259	1110	931	784	698	597		<14%>	<16%>
Feature Phones (FP) - **MI**	1352	1370	1219	1046	814	659	544	394		<26>	<24%>

T Units (M) - Sept 2013 Model (Price segment change)

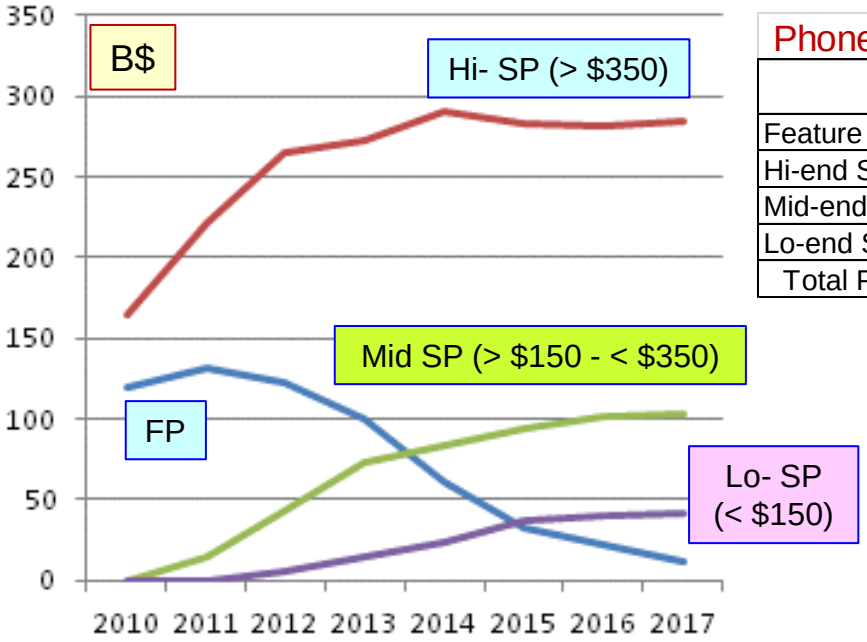
T Units	2010	2011	2012	2013	2014	2015	2016	2017	2018	2013-17 CAGR
Hi-endTs (> $250)	8	38	73	90	104	120	137	158	182	15%
Mid-end Ts ($100 - $250)	4	27	44	64	72	115	159	173	183	28%
Lo-end Ts (< $100 - "WB")	10	25	50	120	199	250	320	410	510	36%
Total T Units (M)	**22**	**90**	**167**	**274**	**375**	**485**	**616**	**741**	**875**	28%

- By 2015 there will be 2B+ SP and T mobile devices
  - By 2017 2.6B but unit growth will markedly slow down
- From IC packaging and processor type point of view
  - Hi-end == Premium device segment
  - Mid- and Lo-end == Mainstream ~~ Emerging Regions segment



SP OEM Revenues by Segment

- SP OEM revenues are in the 6 : 2 : 1 ratio – Hi- to Mid to Lo-end SPs
  - Despite dramatically different unit growth rates (2013-17 CAGR of 7%, 20% and 26%)
  - Hi-end SPs are nearly 3X Mid SP revenue --- Mid SPs are nearly 2X Lo-end SP revenue
  - SPs, especially Hi-end, are becoming personal computing systems beyond 2015 (added growth is likely)



Phone OEM Revenues ($B)

	2010	2011	2012	**2013**	2014	2015	**2016**	2017	2013-2017 CAGR
Feature Phones (FP) 2.5+2.75+3G	120	132	123	100	61	32	22	12	<41%>
Hi-end SP (**> $350**)	165	222	265	**272**	291	283	**281**	285	1%
Mid-end SP (**< $350 - >$150**)	0	14	43	**73**	83	95	**102**	102	9%
Lo-end SP (**< $150 by 2015 < $100**)	0	0	6	**14**	24	37	**39**	42	32%
Total Phone OEM Revenues ($B)	285	368	437	**458**	459	446	**445**	441	0%

Phone ASP Model - Jan 2013

	2010	2011	2012	**2013**	2014	2015	**2016**	2017	2013-2017 CAGR
FP	120	113	107	99	70	53	47	35	<23%>
Hi-end SP (> $350)	550	510	486	**452**	425	404	**375**	356	<6%>
Mid-end SP (< $350 - >$150)		300	253	**215**	185	155	**150**	145	<9%>
Lo-end SP (< $150 by 2015 < $100)			150	**138**	121	109	**98**	82	<12%>

Sources: IC Insights, Credit Suisse, JPMorgan, MI

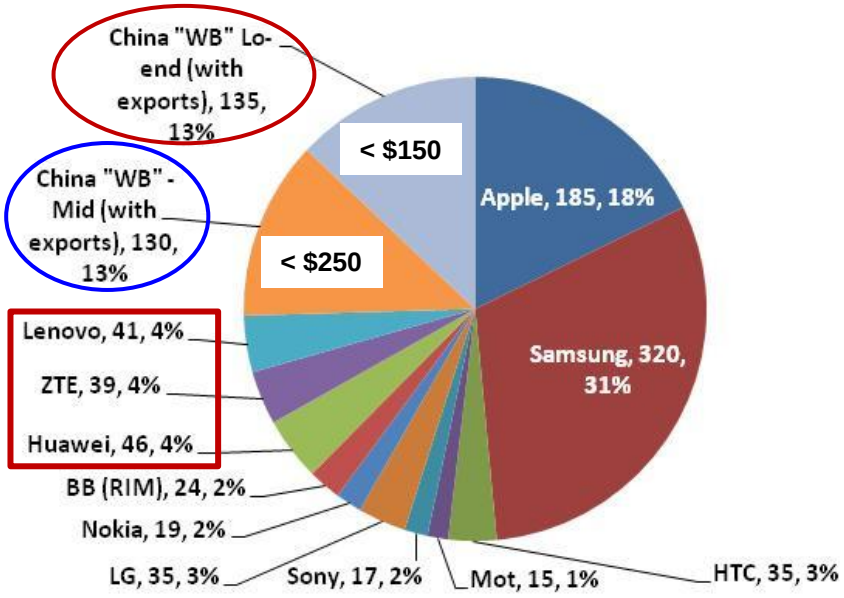
China SP OEMs are Becoming Important to MP Growth

	4Q12
Samsung	64
Apple	48
Huawei	**10.8**
Sony	9.8
ZTE	**9.5**
Other (**LG, HTC, Nokia**, **BB**)	78
Total	219

- In 4Q12 Huawei and ZTE became #3 and #5 SP vendors
  - Likely permanently displacing HTC, BB, Nokia and LG from Top-5 global SP OEMs
- Global expansion of China's phone OEMs in 2013 and beyond (their stated strategy)
  - Their goal is MS gain before SP market growth slows down by 2017 and beyond
  - Primary target of Huawei, ZTE, Lenovo, TCL, others will be Android space – hence Samsung

2013 OEM MS in SPs – All Segments

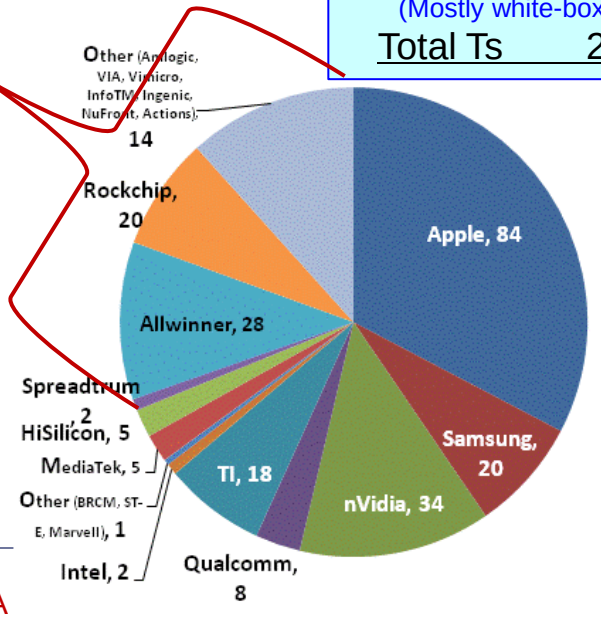
~ 1,040M SPs



107+M T APs "WB" – with exports

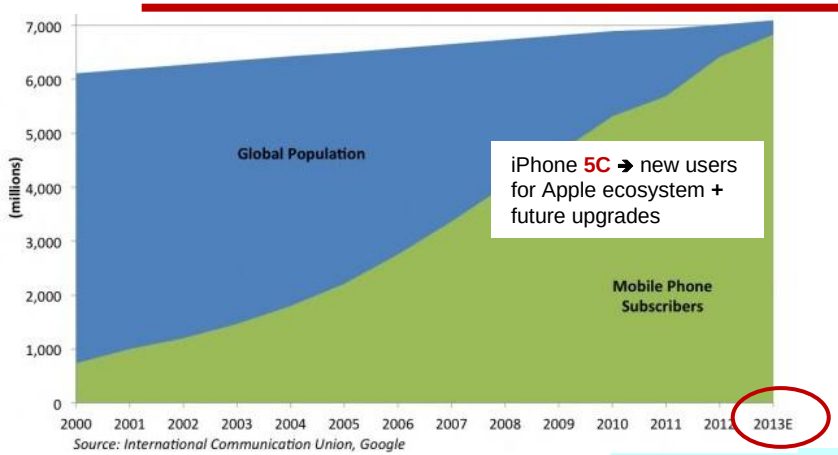
2013 Est. Tablet AP MS

> $100	167M	all FC
< $100	107M+	FC + WB
	(Mostly white-box Ts)	
Total Ts	274M	



Sources: Credit Suisse, MI

90% Phone Penetration in 2013 – 90% FP to SP Conversion by 2018



BRIC population - 2012			
Brazil	194M	India	1,210M
Russia	143M	China	1,354M

Africa	1,133M

Fastest growing population

Global Mobile Phone (FP + SP) Penetration Nears 100% in 2013

After 2018 only SP replacement / upgrade in a 8-10% unit growth market – all regions

China - the 2nd largest economy in 2010

GDP* World Ranking (2010, T$)

1.	USA	14.59
2.	**China**	**5.93**
3.	Japan	5.46
4.	Germany	3.28
5.	France	2.56
6.	UK	2.09
7.	Brazil	2.08
8.	Italy	2.05
9.	India	1.73
10.	Canada	1.58
11.	Russia	1.48
12.	Spain	1.41
13.	Mexico	1.03
14.	Korea	1.02
15.	Australia	1.01

China – the largest economy by 2030

EM (BRIC) 1.25x of Developed Economies

GDP World Ranking (2030E, T$)

1.	**China**	**52.94**
2.	USA	35.06
3.	**India**	**15.92**
4.	**Brazil**	**8.98**
5.	Japan	8.48
6.	**Russia**	**6.89**
7.	Germany	5.92
8.	France	5.22
9.	**Indonesia**	**4.95**
10.	UK	4.73
11.	Canada	4.44
12.	Korea	4.03
13.	Australia	3.69
14.	Italy	3.61
15.	Iran	3.11

88

80

Source: Economics Intelligence Unit (EIU). 2012 updated data; World bank.

2012 -- 39 of Top-50 Cities in EM Countries

1. Tokyo, Japan (37,126,000)
2. **Jakarta, Indonesia (26,063,000)**
3. Seoul, South Korea (22,547,000)
4. **Delhi, India (22,242,000)**
5. **Shanghai, China (20,860,000)**
6. **Manila, Philippines (20,767,000)**
7. **Karachi, Pakistan (20,711,000)**
8. New York, USA (20,464,000)
9. **Sao Paulo, Brazil (20,186,000)**
10. **Mexico City, Mexico (19,463,000)**
11. **Cairo, Egypt (17,816,000)**
12. **Beijing, China (17,311,000)**
13. Osaka, Japan (17,011,000)
14. **Mumbai, India (16,910,000)**
15. **Guangzhou, China (16,827,000)**
16. **Moscow, Russia (15,512,000)**
17. Los Angeles, USA (14,900,000)
18. **Calcutta, India (14,374,000)**
19. **Dhaka, Bangladesh (14,000,000)**
20. **Buenos Aires, Argentina (13,639,000)**
21. **Istanbul, Turkey (13,576,000)**
22. **Rio de Janeiro, Brazil (12,043,000)**
23. **Shenzhen, China (11,885,000)**
24. **Lagos, Nigeria (11,547,000)**
25. Paris, France (10,755,000)
26. Nagoya, Japan (10,027,000)
27. **Lima, Peru (9,121,600)**
28. Chicago, USA (9,121,000)
29. **Kinshasa, Congo (DRC) (9,046,000)**
30. **Tianjin, China (8,922,000)**
31. **Chennai, India (8,865,000)**
32. **Bogota, Colombia (8,702,000)**
33. **Bengaluru, India (8,670,000)**
34. London, United Kingdom (8,586,000)
35. Taipei, Taiwan (8,338,000)
36. **Ho Chi Minh, Vietnam (8,314,000)**
37. **Dongguan, China (8,278,000)**
38. **Hyderabad, India (7,903,000)**
39. **Chengdu, China (7,895,000)**
40. **Lahore, Pakistan (7,743,000)**
41. **Johannesburg, S. Africa (7,618,000)**
42. **Tehran, Iran (7,419,000)**
43. Essen, Germany (7,304,000)
44. **Bangkok, Thailand (7,151,000)**
45. **Hong Kong, Hong Kong (7,106,000)**
46. **Wuhan, China (6,995,000)**
47. **Ahmedabad, India (6,482,000)**
48. **Chongqung, China (6,321,000)**
49. **Baghdad, Iraq (6,204,000)**
50. **Hangzhou, China (6,178,000)**

Mega-cities in EM regions have very fast population growth

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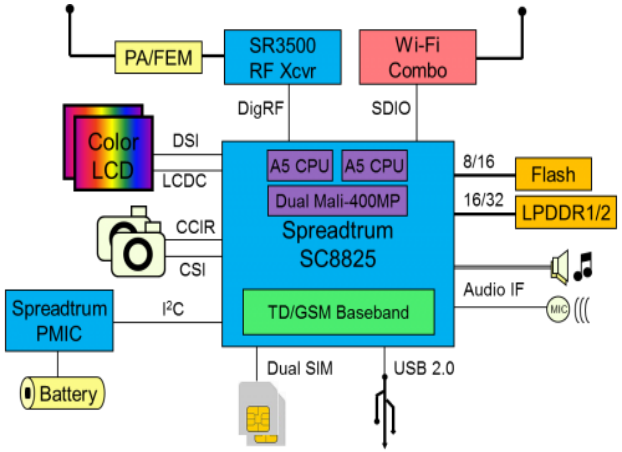
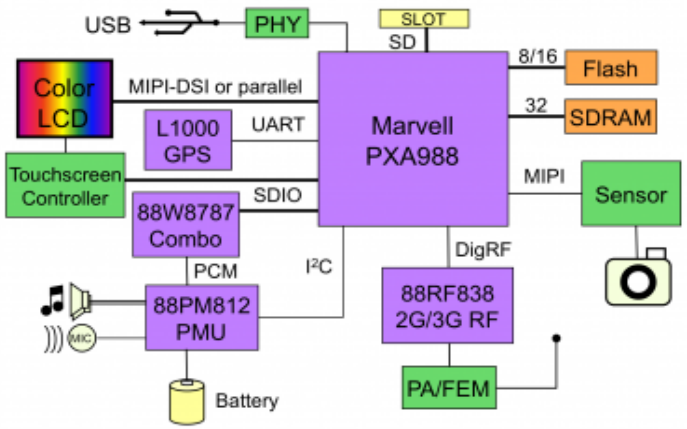
2013 LCSPs – Low Cost PCBs Require >0.4mm Pitch

Spreadtrum SC8825
2-core TD-SCDMA IP
40nm, 4 IC (**all 4 in WB**)
HV in 1Q13 – 12mm2 FBGA



Marvell PXA988
2-core TD-SCDMA IP
40nm, 5 IC (**all 5 in WB**)
HV in 3Q13 – 12mm2 PoP FBGA



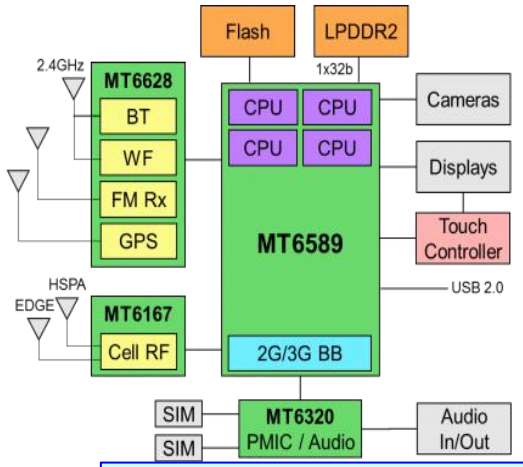
2012 Mid-end SPs are Lo-end SPs in 2013

4-core 28nm MT6589 is bringing Hi-end features and performance to $160+ SPs

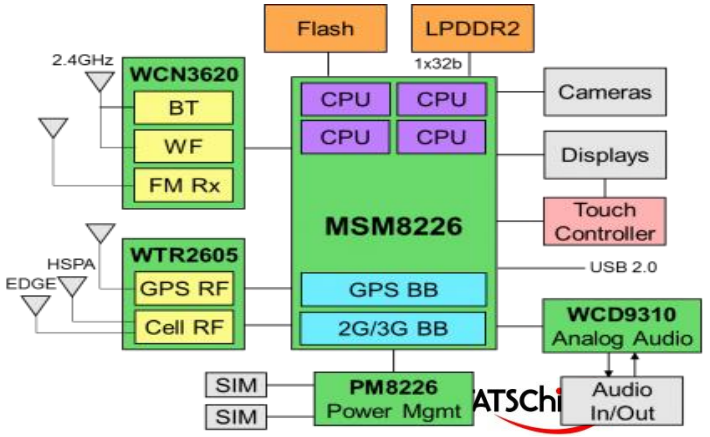
India's JiaYu is selling MTK-based (1-core) phones for $55 (3,000 rupees)

Note that WB dominates – even a SA TD-LTE BB will be in WB (for QTI likely in WLP/eWLP)

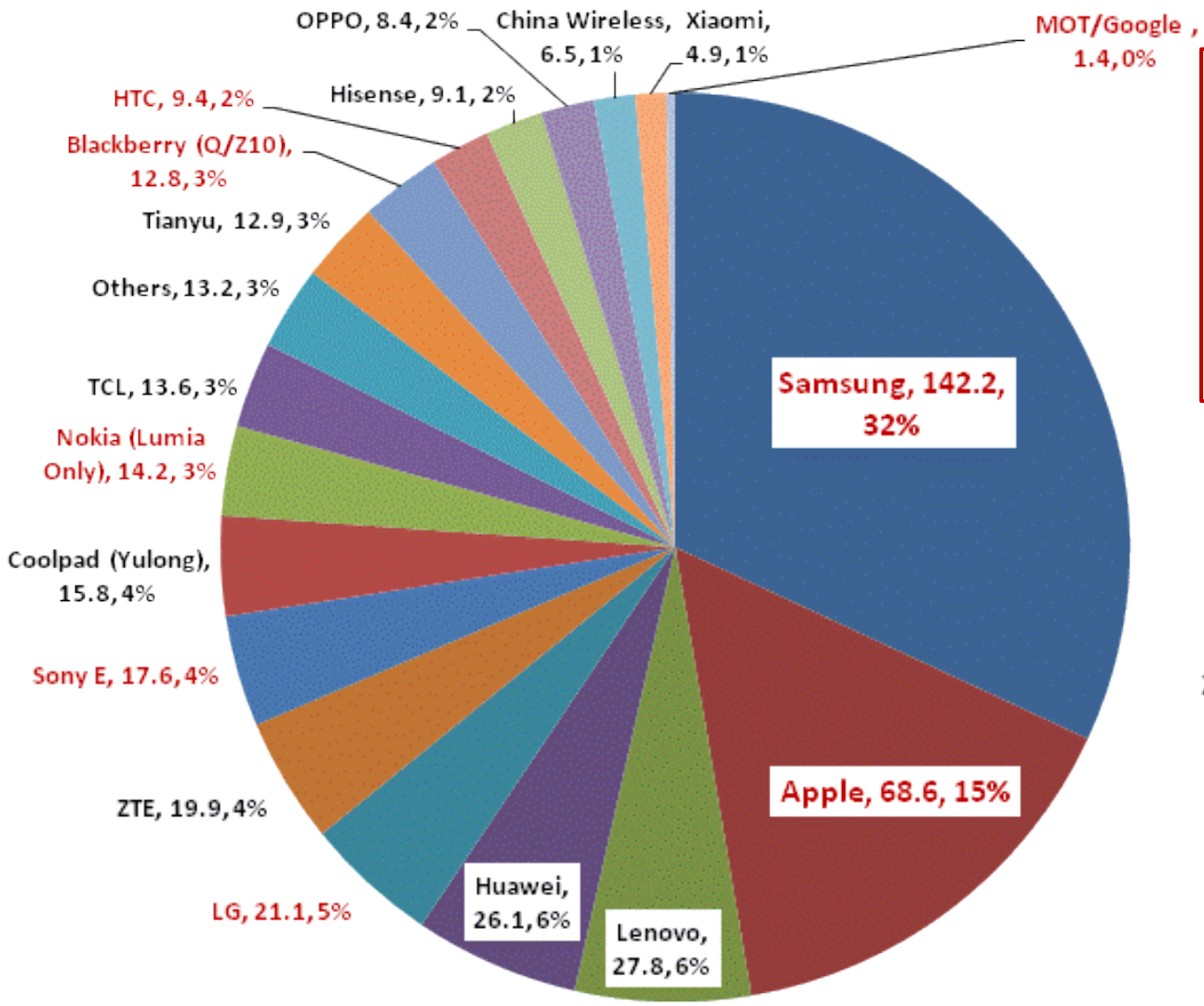
MediaTek MT6589
4-core 3G IP
28nm, 4 IC (**1 FC - 3 WB**)
for TD-SCDMA add XCVR in WB - HV in 1Q13



Qualcomm MSM8226
4-core 3G IP
28nm, 5 IC (**1 in FC – 4 WLP**)
HV in 4Q13



SP OEM MS – 1H13 – SP Units (446M+) > FP Units (403M)

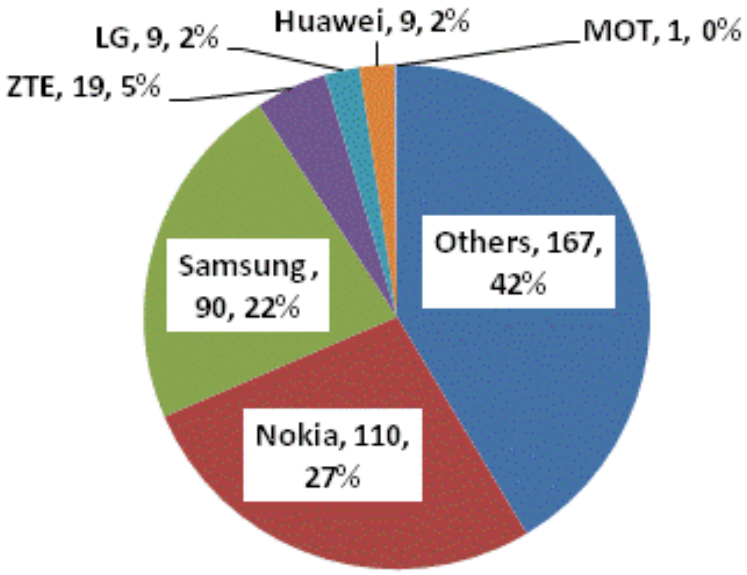


Note – 6-months (1H13)

- Non-China OEM 287M 64%
- China OEM 158M 36%
- Total SPs (1H13) 446M+ 100%

Full 2013 - SP Total 1,040M

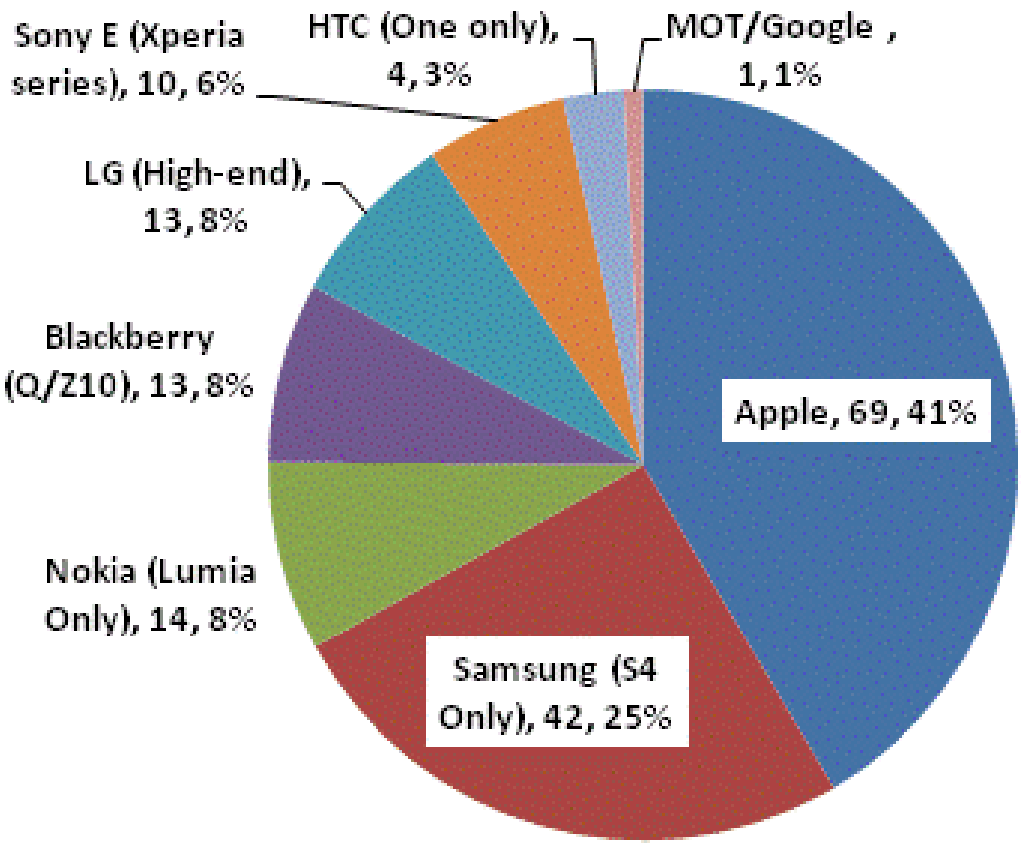
FPs – 1H13 – 403M



Source: Composites sources -- MI Compilation & Estimate, Aug 2013

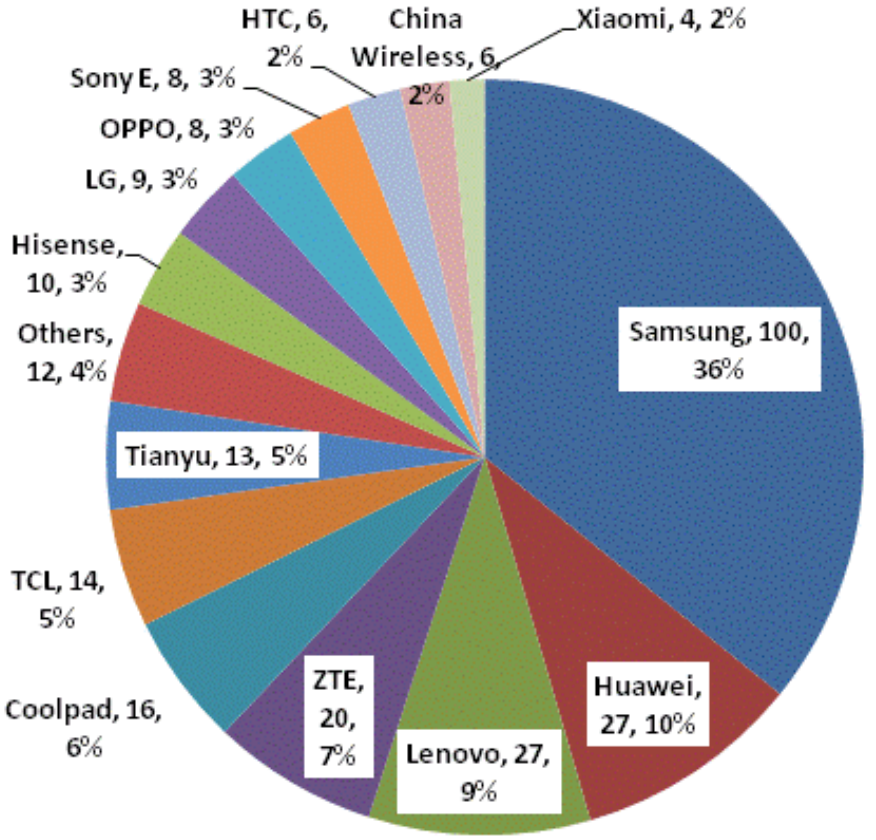
Premium and Mainstream SP OEMs – 1H13

Premium SPs ($350 and above)



167 M or 37%

Mainstream SPs (below $350)

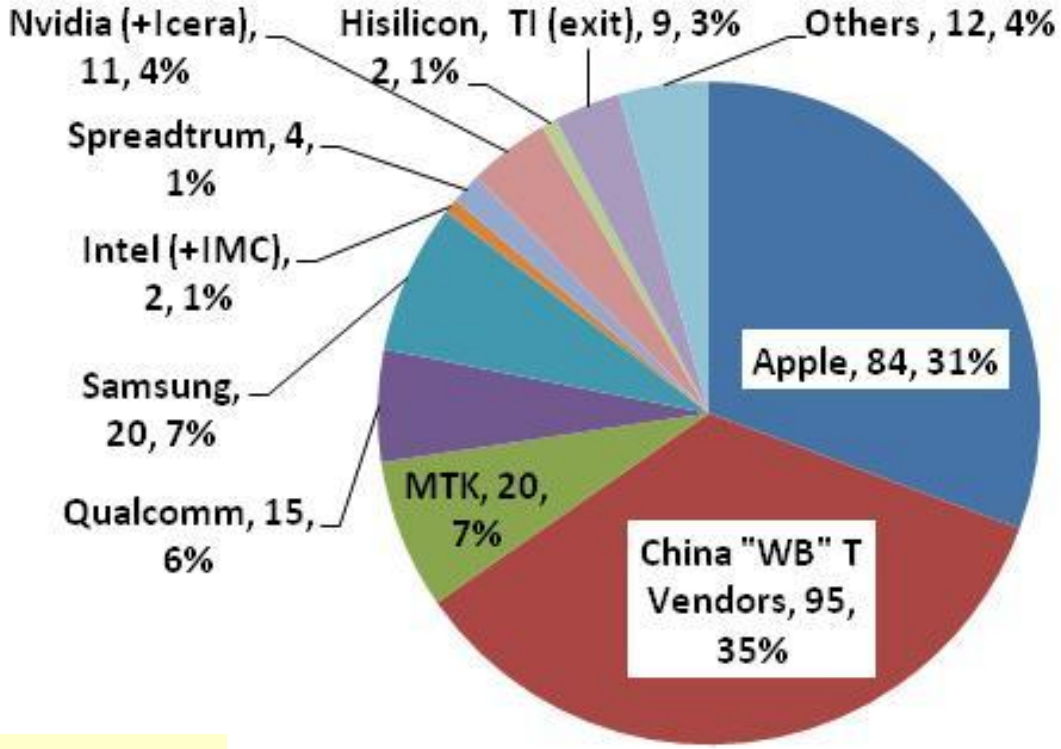


280M or 63%

Non-China OEMs	124M	44%
China OEMs	157M	56%
Total Mainstream	280M	

Source: Composites sources -- MI Compilation & Estimate, Aug 2013

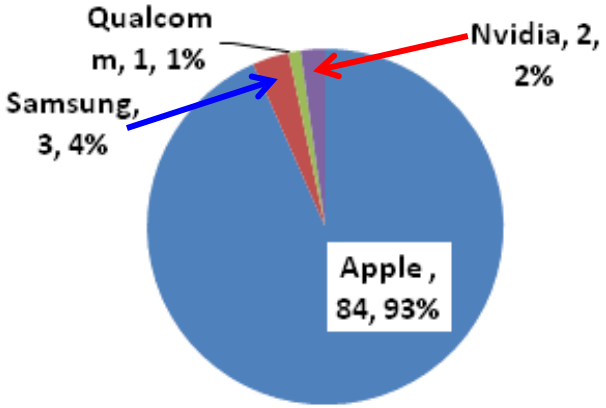
2013 Estimated MS for Tablet Processors – 274M Total



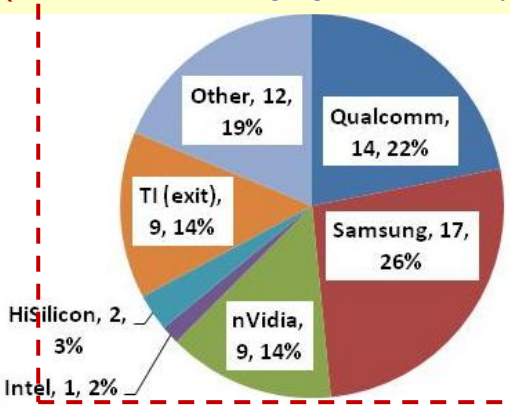
- Premium Ts (Hi-end) are all (93%+) Apple only
  - iPad and iPad-Mini (>$250)
- Mainstream Ts (Mid + Lo-end) are increasingly dominated by China AP vendors
  - China AP vendors are penetrating Taiwan and US (HP, Dell) vendors for Ts up to $200

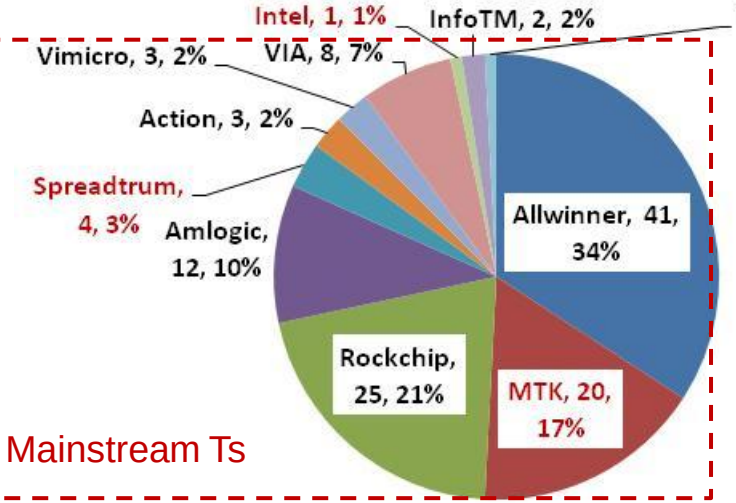
Lo-end Tablets < $100 (120M units) – China AP vendors 99M (83% of total)

Hi-end Tablets > $250 (90M units)



Mid-end Ts $250--$100 (64M units – merging with Lo-end)





Mainstream Ts

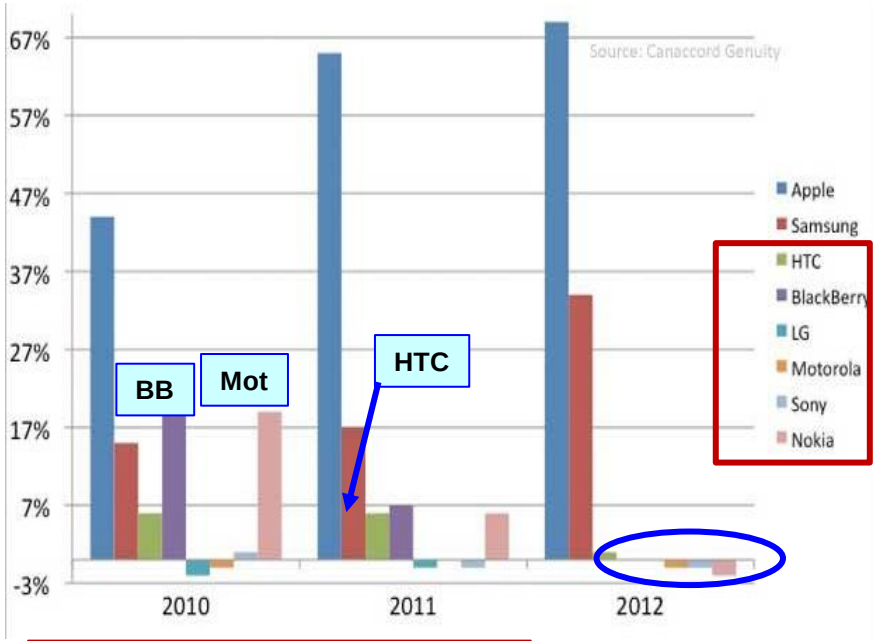
Mobile OEM Profitability Landscape

- Samsung has resources and scale to develop and fabricate its own platform
  - LG, HTC and Lenovo will continue to reassess their possible entry into costly mobile platforms
- Among Mobile IC vendors consolidation and exits will continue
  - ST-E and Renesas have exited; future of 3-4 other is far from certain
- Several phone OEMs – Nokia/MSFT, BB, Sony and HTC also have an uncertain future

Declining number of IC vendors offering mobile platforms has strategy implications

In 2012 Apple and Samsung completely dominated profits of phone OEMs

Operating Profit – Value Share by Phone OEMs



Source: Canaccord Genuity, Feb. 2013

Landscape is still very dynamic:

– Apple just introduced 64-bit AP
-- ZTE (and others) has introduced SPs using Firefox OS
-- Samsung abandoned internal Badu OS
  - It plans to introduce Tizen OS
-- Google launched a powerful Cloud/"thin" client
-- Intel is designing Atom for Android and Windows SPs
-- LG also to make 8-core APs – SPs and DTV (in 2013), etc.
-- Facebook, Amazon, others to launch SPs

China OEMs -- Hyper-growth At Present ~~50% for export

In 1Q12 ZTE and Huawei SP unit volume was where Samsung was only two years ago (in 1Q10)

The SP race is far from finished but – it will likely be finished by 2016

MP race will likely be finished in 2014

Samsung 56.3M SPs in 3Q12

Apple 26.9M SPs in 3Q12

China 2nd Tier and shanzai vendors account for 20M+ SPs in China in 3Q12 – growing ~2+ times faster than Samsung

- What was missing in the original chart is the very high growth of China's OEMs
  - Including 2nd Tier and "white box shanzai" vendors which grow at 200%+ (see ★)
  - Possibly 160M+ SPs in 2013 ←→ strong export to Emerging regions

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2013 Phone BOM for Three SP Segments

Ts are similar except (usually) without phone functionality (BB+XCVR)

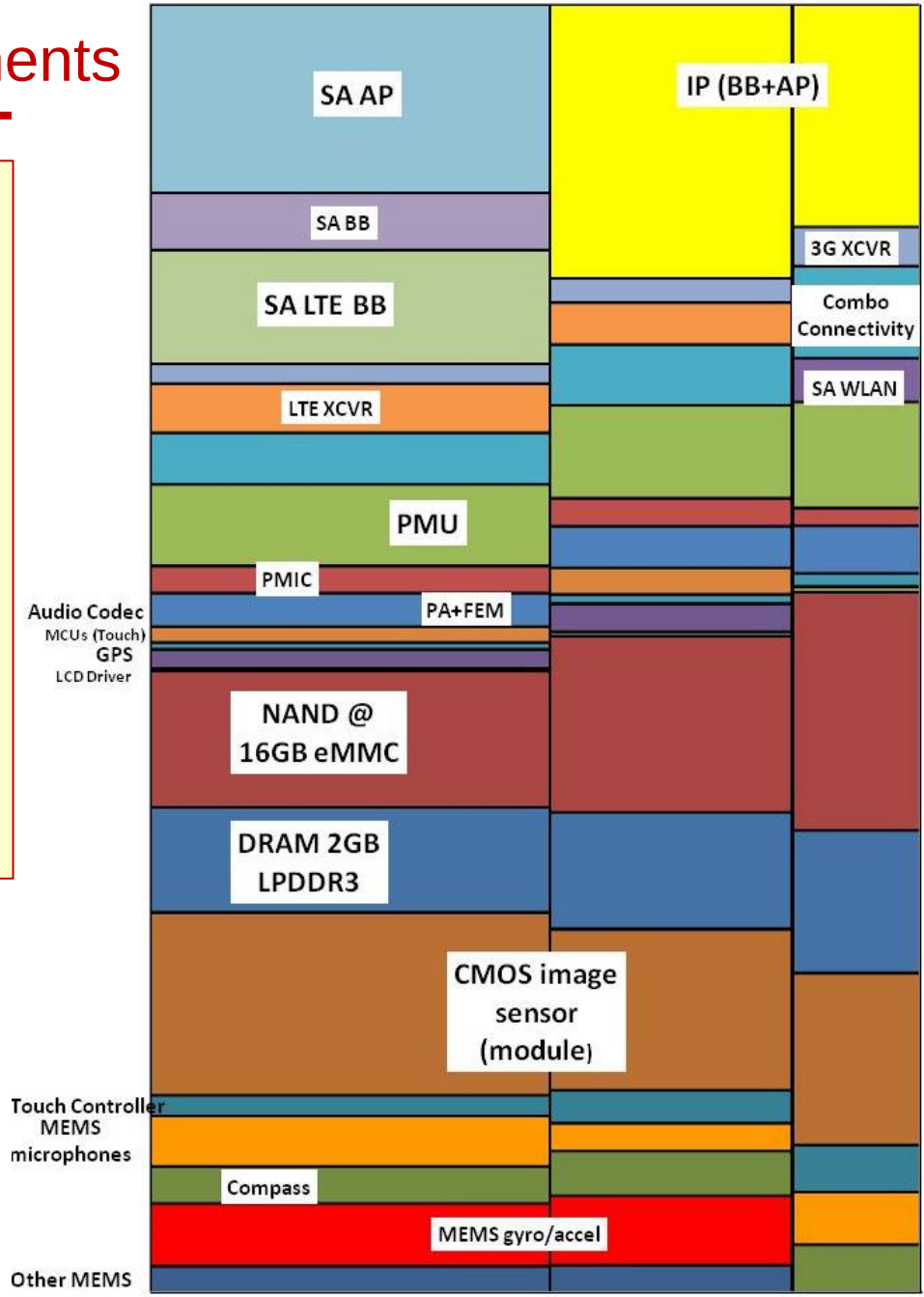
	Hi-end >$350	Mid-end	Lo-end <$150	
BOM	246	146	93	
Non-IC (display, touch panel, battery, PCB, camera, test, discretes, passives, connectors)	119	66	52	
Labor (not in BOM)	12	10	6	
SP ICs	124	74	39	
Processors (SA BB, SA AP, IP)	**35.6**	**16.4**	**7.0**	
SP Platform (Chipset) ICs	**22.2**	**15.1**	**7.8**	
3G XCVR	2.0	1.5	1.3	
LTE XCVR	4.8	2.5		
Connectivity Combo	5.1	3.6	2.9	Combos will decline -- processor-integrated
SA WLAN			1.4	
PMU	4.1	2.8	1.7	
PMIC	2.7	1.6	0.5	
Audio Codec	1.6	1.4		
SA GPS	1.9	1.7		
All Other ICs	**65.8**	**42.6**	**24.2**	
Other ICs w/o Memory + CIS	**23.9**	**15.5**	**6.8**	
Power amplifier + FEM	3.4	2.5	1.5	
MCU	0.6	0.5	0.4	
LCD Drivers	0.3	0.3	0.2	
NAND Memory	**13.4**	**10.5**	**7.5**	Typically excluded from further analyses since not served by SCL
DRAM Memory	**10.5**	**7.0**	**4.5**	
CMOS Image Sensor	**18.0**	**9.6**	**5.4**	
Touch controller	2.1	2	1.5	
All MEMS	17.5	10.2	3.2	

2013 BOM Model for Three SP Segments

		Hi-end SP (>$350)	Mid SP ($150-$350)	Lo-end SP (<$150)
	SA AP	$18.6		
	SA BB	$5.7		
	SA LTE BB	$11.3		
	IP (BB+AP)		$16.4	$7.0
	3G XCVR	$2.0	$1.5	$1.3
	LTE XCVR	$4.8	$2.5	
	Combo Connectivity	$5.1	$3.6	$2.9
	SA WLAN			$1.4
	PMU (multiple in Quad ?)	$8.1	$5.6	$3.4
	PMIC ($0.54 analog 5 to 1)	$2.7	$1.6	$0.5
	PA+FEM (switch, tuner)	$3.4	$2.5	$1.5
	Audio Codec	$1.6	$1.6	
	MCUs (Touch)	$0.6	$0.5	$0.4
	GPS	$1.9	$1.7	
	LCD Driver	$0.3	$0.3	$0.2
	NAND @ 16GB eMMC	$13.4	$10.5	$7.5
	DRAM 2GB LPDDR3	$10.5	$7.0	$4.5
	CMOS image sensor (module)	$18.0	$9.6	$5.4
	Touch Controller	$2.1	$2.0	$1.5
	MEMS microphones (3 in Hi-end	$5.0	$1.7	$1.7
	Compass (Magnetic)	$3.7	$2.7	$1.5
	MEMS gyro/accel	$6.2	$4.2	
	Other MEMS	$2.6	$1.6	
Non ICs	Display/Touch Panel	$75.0	$40.0	$32.0
	Li battery	$6.0	$4.5	$4.5
	PCB	$6.0	$4.3	$2.7
	Camera lens	$22.0	$12.0	$10.0
	Speaker			
	Connectors			
	Test + FA			
	Discretes + Passives	$10.0	$4.5	$3.3
Total IC Cost		**$127.3**	**$80.8**	**$40.6**
Total BOM		**$246.3**	**$146.1**	**$93.0**
Assembly - labor		$12	$10	$8
IC / BOM %		52%	55%	44%

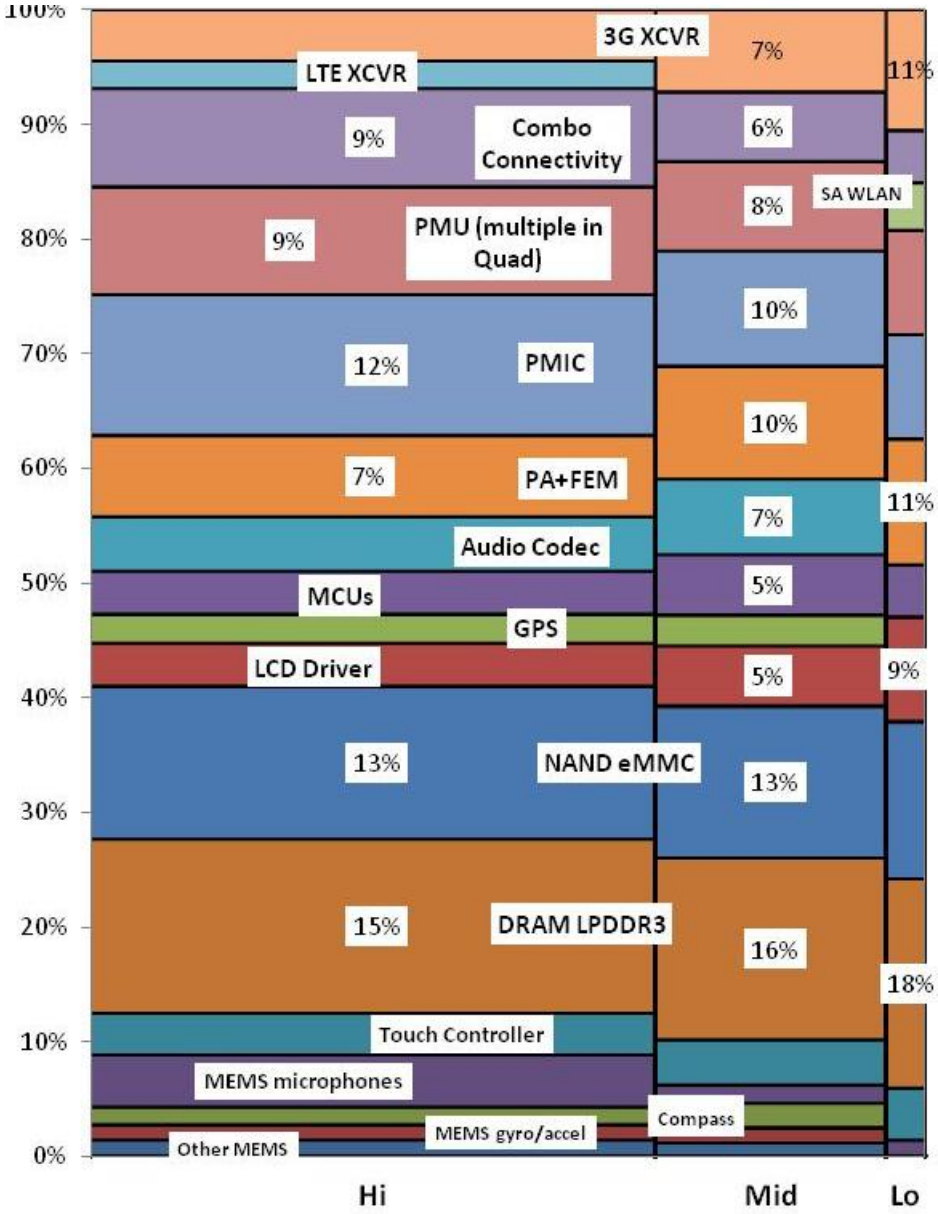
The chart represents IC ASPs in normalized phone BOMs:
Hi- ICs $127
Mid-ICs $81
Lo- ICs $41

PMUs are overestimated – PMU/core assumption has never materialized



Non Processor Overview -- 2013 Packaging TAM for SP

(excluding CIS Modules)



- In 2013 $79B Non-P SP ICs will account for **$4.7B** T+A packaging SAT revenues
  - Hi- 68%, Mid- 28%, Lo-end SPs 5%

2013

	2013 IC Rev (B$)	Packaging TAM (M$) Hi	Mid	Lo
3G XCVR	1.4	140.4	91.8	23.0
LTE XCVR	0.8	76.0		
Combo Connectivity	4.5	270.5	78.2	10.0
SA WLAN	0.1			9.0
PMU (multiple in Quad) (~2x overestimated)	7.1	297.0	100.0	20.0
PMIC (analog 5 to 1)	2.2	390.0	130.0	20.0
PA+FEM (switch, tuner)	3.0	222.4	125.8	24.0
Audio Codec	1.6	150.3	85.0	
MCUs (Touch)	0.6	120.0	68.0	10.0
GPS	1.7	78.1	34.0	
LCD Driver	0.3	120.0	68.0	20.0
NAND (16GB-Hi) eMMC	14.0	420.7	170.0	30.0
DRAM (2GB-Hi) LPDDR3	10.9	480.8	204.0	40.0
CMOS image sensor (module)	14.6	n.a.	n.a.	n.a.
Touch Controller	2.1	114.2	51.0	10.0
MEMS mikes (3 in Hi-end)	3.7	144.0	20.4	3.0
Compass (Magnetic)	3.3	48.1	27.2	
MEMS gyro/accel	5.1	42.1	17.0	
Other MEMS	2.1	45.0	15.0	
Total SP Non-MP Revenue	**79.0**	**3159**	**1285**	**219**
		4663		
		Without CIS Image Sensor		

SP and T Units by Segment – Note: Units Not Updated

- Mobile processors have high (20%+) unit growth rates in
  - Mid and especially Lo-end SPs and all T segments
  - Significant OSAT ASP erosion in 2013 and beyond because of dramatic mix and other changes
- Drastic cost reduction in Mobile IC packaging is no longer "optional"

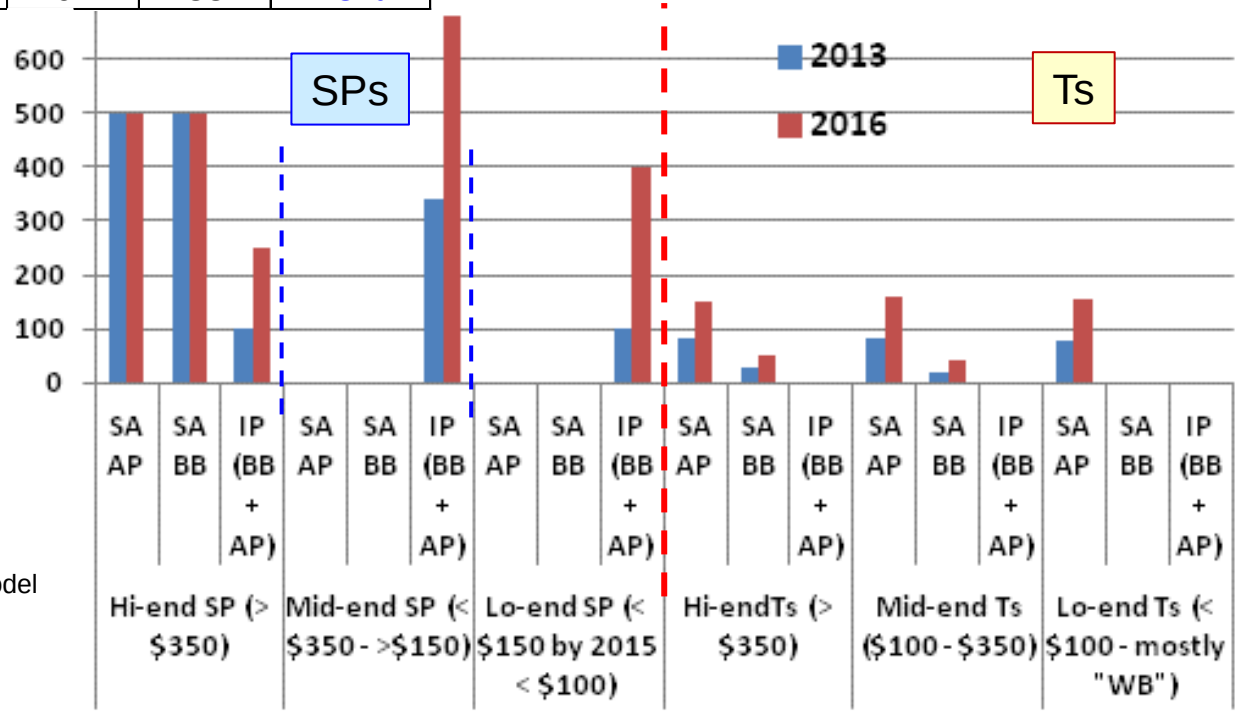
SP Units (M) - Jan 2013 MI Model

	2013	2016	2013-2017 CAGR
Hi-end SP (> $350)	601	750	7%
Mid-end SP (< $350 - >$150)	340	680	20%
Lo-end SP (< $150 by 2015 < $100)	100	401	50%
Total SP Units (M)	1041	1831	18%

T Units (M) - Jan 2013 MI Model

	2013	2016	2013-17 CAGR
Hi-endTs (> $350)	84	150	21%
Mid-end Ts ($100 - $350)	83	160	25%
Lo-end Ts (< $100 - mostly "WB")	80	156	25%
Total T Units (M)	247	466	24%

Processor Type
By Price Range (M Units)



Note: A possible MI model weakness is an underestimate of Hi-end IP processors by 2016
-- Key insights, however, would not change

Source: MI Jan 2013 model

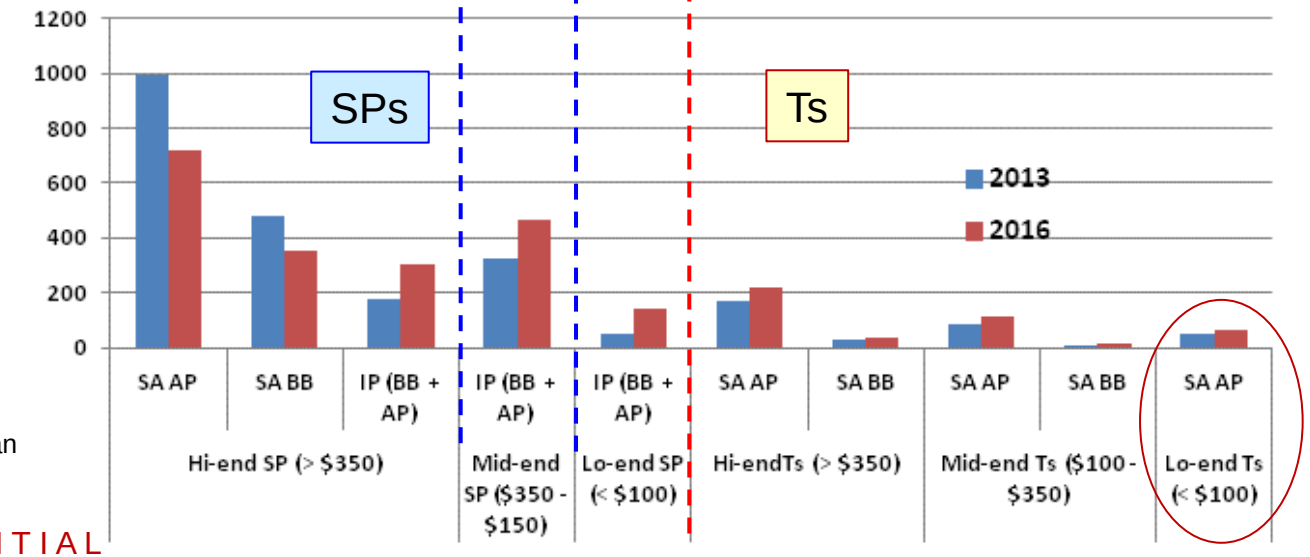
MP Total Packaging (SAT) Revenues – Likely Stay Flat (2013 - 2016)

- Flat SAT revenues in Mobile Processors (SP and T) -- $2.4B in 2013 and $2.5B in 2016
  - Hi-end SP $1.7B in 2013 and **$1.4B** in 2016 -- Hi-end T $200M in 2013 and **$250M** in 2016
  - Mid SP $300M in 2013 and **$500M** in 2016 -- Mid T $100M in 2013 and **$120M** in 2016
  - Lo-end SP $50M in 2013 and **$150M** in 2016 -- Lo-end T $50M in 2013 and **$70M** in 2016
  - China OSATs are emerging – especially JCET/JCAP ~$700M and ~11+% growth in 2012
  - Threat from foundries' entry

		2013	2016
Hi-end SP (> $350)	SA AP	992	720
	SA BB	481	355
	IP (BB + AP)	180	308
Mid-end SP ($350 - $150)	IP (BB + AP)	323	469
Lo-end SP (< $100)	IP (BB + AP)	48	144
Total SP Processors (M$)		2024	1996

		2013	2016
Hi-endTs (> $350)	SA AP	169	219
	SA BB	27	36
Mid-end Ts ($100 - $350)	SA AP	83	117
	SA BB	12	16
Lo-end Ts (< $100)	SA AP	48	69
Total T Processors (M$)		338	456

MP SAT Rev (M$)



Source: MI Jan 2013 model

2016 SP OEM "Corner" Scenarios

Four scenarios among numerous considered

- Two Premium SP (>$350) scenarios (525M SPs)
  - Scenario A – Premium SPs dominated by Apple
    - Apple has 71% unit MS in 2016 (372M, 39% CAGR) – Samsung 16% (85M), other 13% (68M)
    - We assume that "budget" iPhone is in the Premium segment – legacy versions in Mainstream
  - Scenario B – Samsung (and others) successful in Premium SPs against Apple
    - Samsung has 35% unit MS (185M, 30% CAGR) – Apple 36% MS (11% CAGR)

- Two Mainstream SP (<$350) scenarios (1206 SPs)
  - Scenario A – China OEMs are able to reduce Samsung's current high growth
    - China OEMs have 65% unit MS in 2016 (776M, 35% CAGR) – Samsung 19% (230M and only 5% CAGR), Apple 7% (90M – legacy (old versions) of "budget" iPhone)
  - Scenario B – Samsung continues its high-growth (25% CAGR)
    - China OEMs have 52% unit MS in 2016 (626M, 25% CAGR) – Samsung holds 32% MS (390M), Apple 7% (90M)

2016 T "Corner" Scenarios – 616M Ts Total

Four Scenarios among numerous considered

Two Premium Ts (>$250) scenarios – 137M Ts

- Scenario A -- Apple completely dominates Premium T segment
  - Intel-based SA Ts marginally successful
- Scenario B – Intel obtains 50% MS of Premium SA T segment
  - Laptops (2-in-1) and desktops (All-in-1) solutions may also have detachable screen
  - These are Ts (if with a separate Atom (Android OS) processor (or even Haswell processor) and battery but they are not counted (double-counting)

Two Mainstream T (>$250) scenarios – ~480M Ts total

- Scenario A – China "White-box" processor vendors highly successful in unit MS
  - "WB" vendors are already gaining MS in higher-priced ($200+) Ts
  - Use of wire-bond for 4-core in 28nm and 20nm, although demonstrably feasible, is not likely ➔ SCL's finding that use of FC is mandatory remains correct but - closely monitor
- Scenario B – SP processor vendors and Intel Atom are able to counterbalance China's "White-box" processor vendors

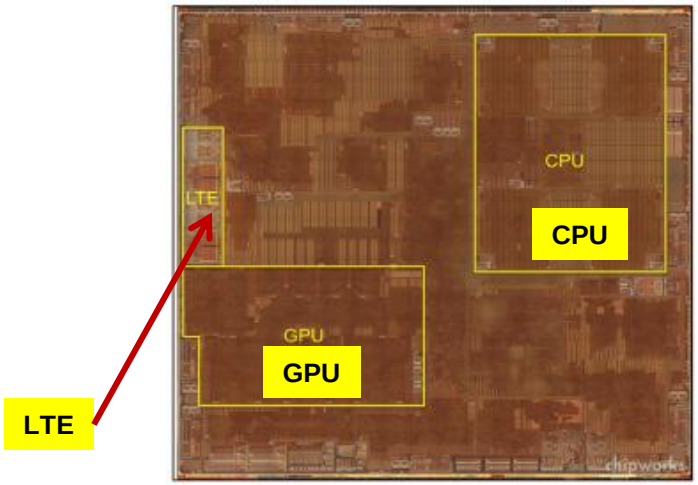
Market and Packaging Trends Overview

- Mobile processors are mostly FC – especially 4-core processors
  - Rockchip and Allwinner are temporary exceptions
- Non-processor ICs are largely wire-bond (especially Mainstream segment) and WLP
  - Qualcomm's LTE XCVR (WTR family) in – WLP
- The importance of Carrier Aggregation functionality in Advanced LTE (LTE-A)
- Emergence of FO-WLP technologies – profound packaging implications for mobile ICs

- Emergence of MediaTek (100% growth in 2013) and Spreadtrum (300% growth in 2013
- Intel's entry into SPs and Ts
- Rise of mega-cities will likely accelerate LTE adoption (FD and TD)
  - LTE growth likely faster than 3G telecommunication standard
- Battle of cloud-based ecosystems – Apple, Amazon, Google, MSFT, other
- MSFT/Nokia – the 3rd OS

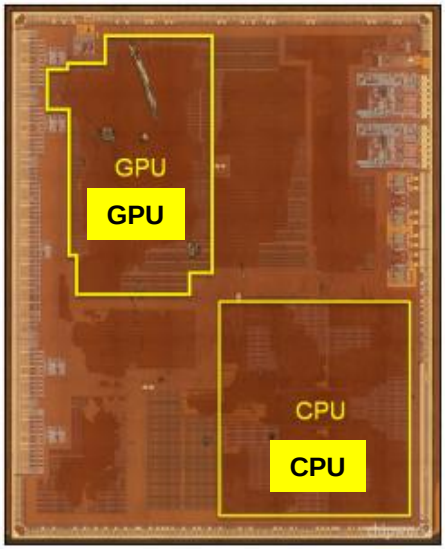
Two Extreme Ends of 28nm 4-core MPs

- Snapdragon 800 MSM8974 – Hi-end LTE IP
  - Caffeine version Bare Die FC PoP
    - Thinner (Z-dimension) ➔ customer preference
- 2.3GHz (the latest ARM-Krait 400 CPU) and 450MHz Adreno 330 GPU
  - Die size is ~118mm2
- Fabricated on TSMC 28HPM high-k metal gate (HKMG) process
  - All previous QTI processors were made on TSMC 28LP poly/SiON process



MSM8974 die

- Rockchip RK3188 Tablet AP ($6+ ASP)
  - 4-core Cortex-A9 – up to 1.6GHz + Mali GPU
  - TFBGA 453b 0.8mm pitch 19x19mm2 ← WB
  - 4L 1-2-1 substrate Cu bonding wire
  - Die size ~25mm2
- Fabricated on GF 28SLP HKMG process
  - It uses bulk silicon (not SOI as AMD)
  - Wire-bond interconnect will likely be transitory

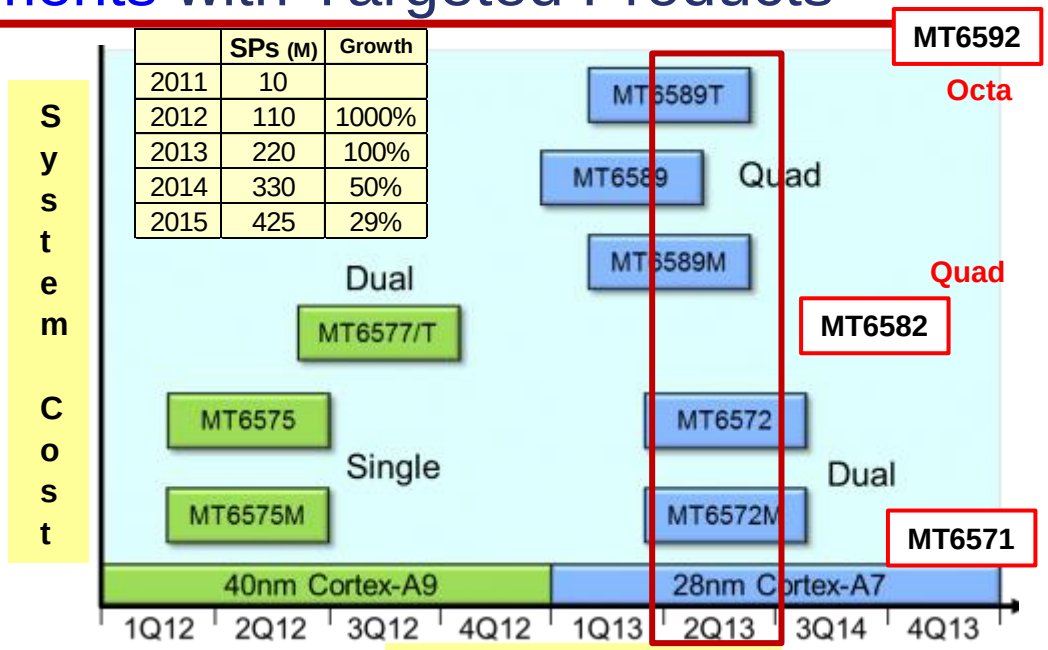


RK3188 die

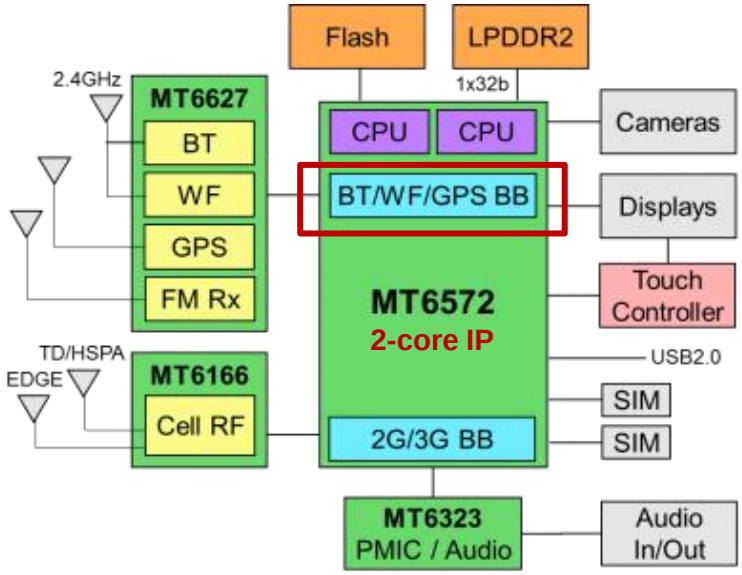
Note: Allwiner 4-core Cortex A7 PBGA in 40nm 0.65nm 609b 18mm2

MediaTek – Blanketing EM Segments with Targeted Products

- In 2Q13 MediaTek continued its rapid introduction of fine-tuned products for EM
  - MediaTek is leaving no stone unturned
  - It is also introducing premium features and advanced technologies into its targeted EM
    - First triple-SIM solution for 3G SPs (LG's Optimus L4ii in Brazil)
    - First HMP (heterogeneous) processing (matching tasks with right cores) – 4-core MT8135 for Ts
    - First "true" 8-core MT6592/99 processors (all eight cores can be used simultaneously)



- Example One: M and T product variants (not just speed binning)
  - MT6589**T** (Turbo) supports 1.5GHz (versus 1.2GHz for MT6589) but also full-HD display
  - MT6589**M** steps down graphics and multimedia performance to match lower-resolution cameras and displays
- Example Two: Digital portion of Combo in IP processor
  - QTI was the first to add the digital portion of Combo into its MSM8960
  - MT6572 is the first to do so for EM SPs, where the cost saving is vital
  - Moving the digital portion of Combo into 28nm reduces cost (size) while using a less expensive RF-process for the remaining Combo
  - It also lowers system cost – all timing for various radios is on one die; this eliminates two crystals (~$1.12) and allows lower PCB cost (four layers instead six layers)



CA – Wider Bandwidth by Using Multiple Frequency Carriers

Leverage wider bandwidth

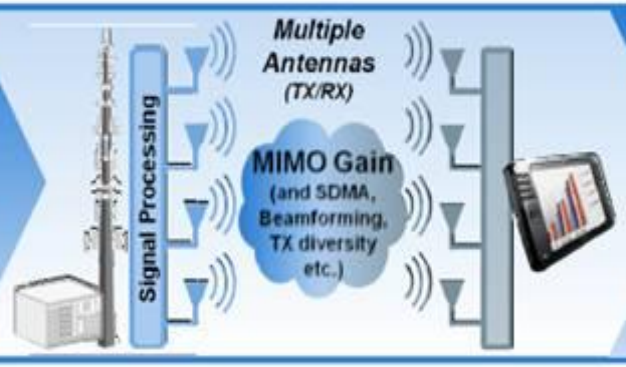
Carrier aggregation across multiple carriers and multiple bands

Primarily higher data rates

(bps)

Leverage more radio links, more antennas

Downlink MIMO up to 8x8, enhanced Multi User MIMO and uplink MIMO up to 4x4

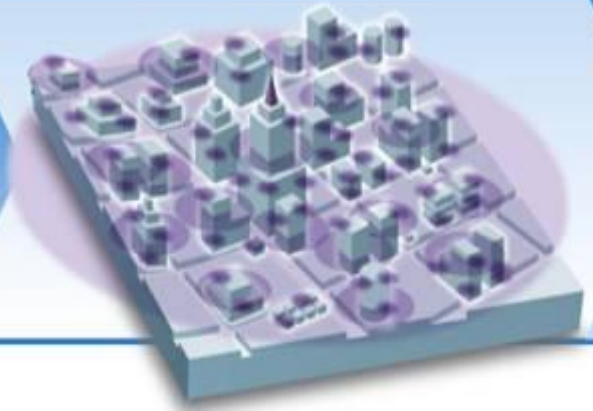


Higher spectral efficiency

(bps/Hz)

Leverage heterogeneous network topology (HetNet)

With advanced interference management (low power picocells with adaptive resource partitioning and advanced receiver based devices)



Higher spectral efficiency per coverage area

(bps/Hz/km^2)