Internet of Things (IoT) and its impact on Semiconductor Packaging

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What is the IoT?

From Wikipedia: The *Internet of Things* (IoT) is the interconnection of uniquely identifiable embedded computing devices within the existing *Internet* infrastructure.

From IBM: The *Internet of Things* represents an evolution in which objects are capable of interacting with other objects.

Fro
netv
hea

CONNECTING

From Forbes: *Internet of Things* (IoT), simply put this is the concept of basically connecting any device with an on and off switch to the Internet (and/or to each other).

The origination of IoT

Originally published in RFID Journal in June 2009 as "That Internet of Things Thing: In the real world, things matter more than ideas".

Today computers—an ... ndent on human beings for information. N ... f data available on the ... record bu ... t ... e ... ta ... Y ... n are impo ... ent on data origina ... we had computers that kne ... a they gathered without any help from us—we would ... count everything, and greatly reduce waste, loss and cost. We would know whe ... ngs needed replacing, repairing or recalling, and whether they were fresh or past their best. {The Internet of Things has the potential to change the world, just as the Internet did. Maybe even more so.}

"The *Internet of Things* has the potential to change the world, just as the Internet did. Maybe even more so." Kevin Ashton

Kevin Ashton, *"That 'Internet of Things' Thing"*, *RFID Journal*, *July 22, 2009*

Part of a speech made at P&G in 2009, linking the benefits of RFID to P&G's Supply Chain

The Internet of Things……… (IoT)

First

Second

Third

Fourth

Industrial Revolution

"anything" with a unique identifier can connect over the internet……

Connectivity
- Anyplace
- Anywhere
- Any path
- Anynetwork

Collections
- Any service
- Any business

Convergenece
- Anytime
- Anything
- Any device

Computing
- Anyone
- Anybody
- Any device
- Any sensor

Internet of Things (iOT)

Source: https://www.multisource.co.za/mediafiles/IOT-001.png

“anything” …..

“Wearables”

Smartphones

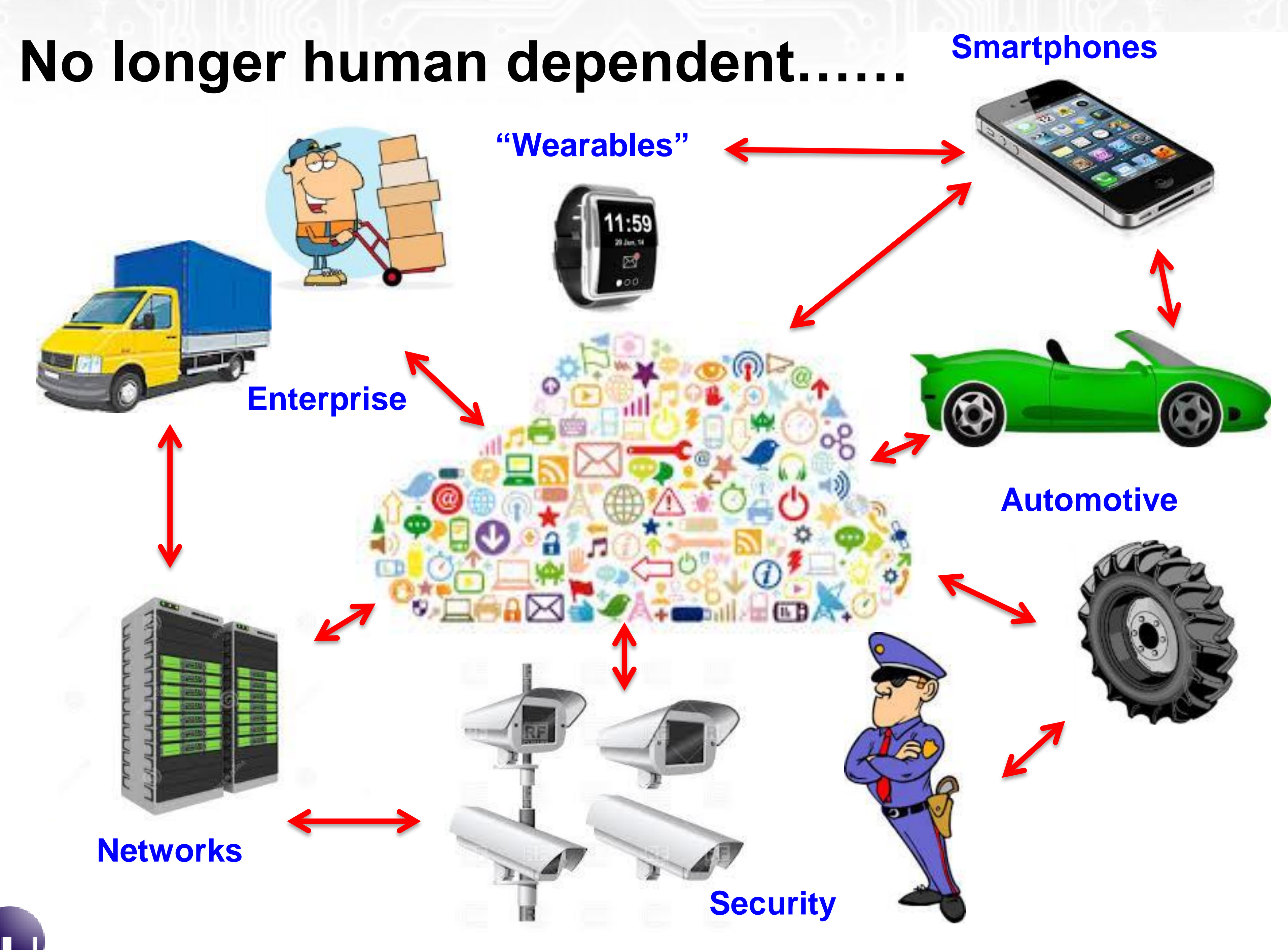
Enterprise

Automotive

Networks

Security

No longer human dependent……



	2003	2010	2015	2020
World Population	6.3 B	6.8 B	7.2 B	7.6 B
Connected Devices	500 M	12.5 B	25 B	50 B
Connected Devices by Person	0.08	1.84	3.47	6.58

IoT Birth
2008-2009

More connected Devices than People

Source: http://www.cisco.com/web/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf

IC Market & IoT:

IC market is slowing and needs the next killer application to fuel growth!

- 2014 Electronics Market ~$1.5 Trillion
  - IC Market $338B (23%) and slowing to 4.6% CAGR
  - Total Package Assembly & Test $52.8B (16%) with Outsource slowing to 5.8% CAGR

➢ **IoT** is projected to be that *killer apps* with 50B devices to be connected by 2020 approaching a $2 Trillion Electronics Market

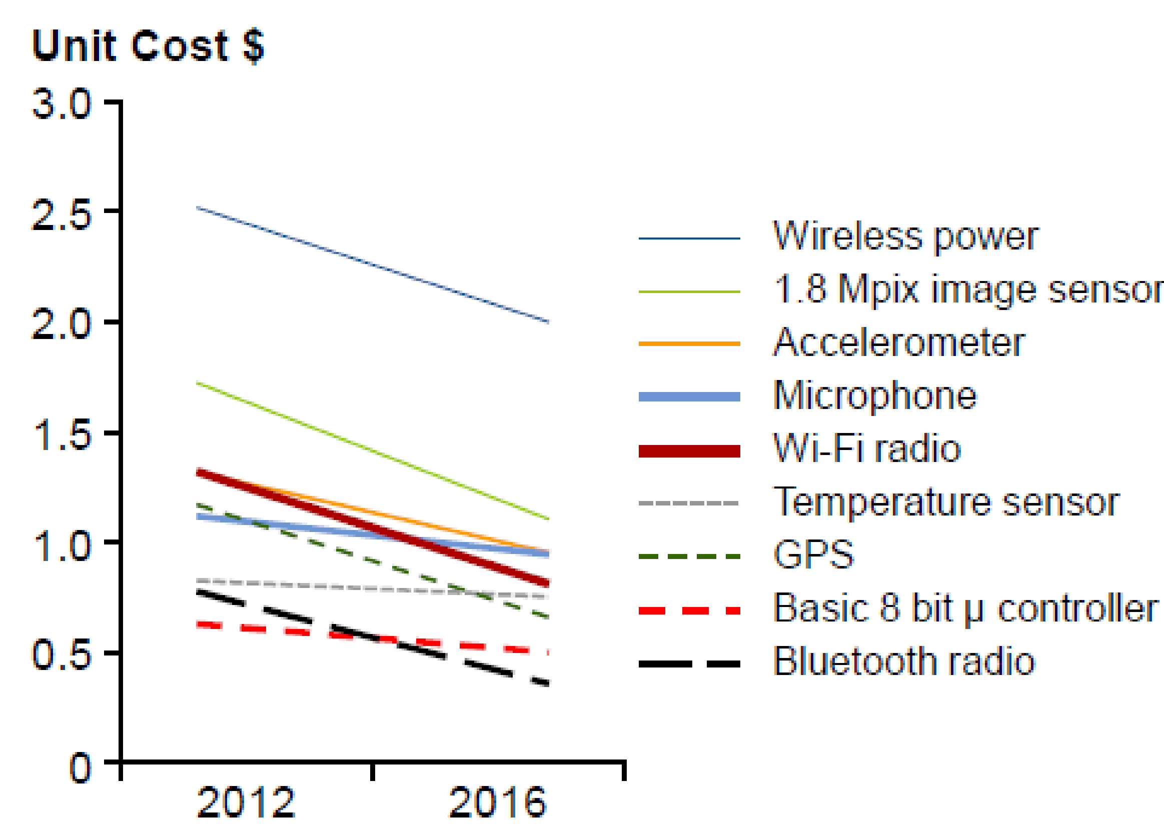
If Bullish Forecasts track to Electronics, IC's and Assembly & Test Markets, 2020 could look like:

Source: Gartner IoT 2014, Techsearch 2014, Google Image

IoT Component Costs Are Falling; Enabling New Applications….

Much of the core technology is common

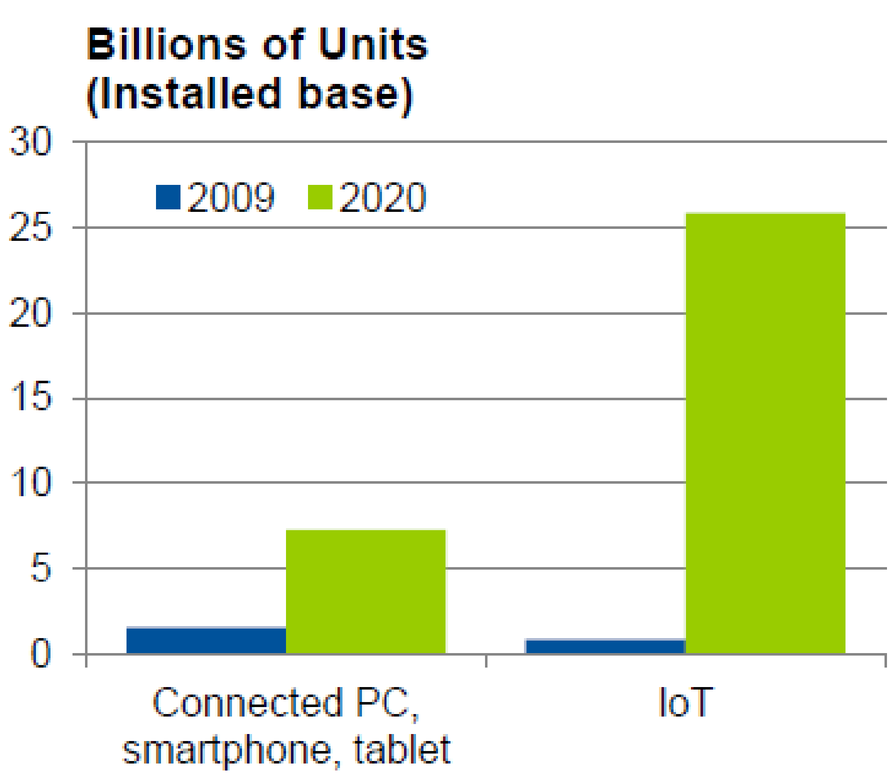
- Computing element
- Embedded software
- Connectivity technology
- Energy source
- I/O for sensors, actuators, etc.



Technology costs are already low enough; just needs service/app idea and business case

Growth of Things Will Be Rapid….

- Growth will far exceed other connected devices
- Risk: infrastructure may not cope for media-centric devices
- 'Ghost' devices with unused connectivity will be common



Expect Many Types of Things; Fragmented Market

By 2017, 50% of Internet of Things solutions will originate in startups less than three years old.

- Expect 10 billion shipments in 2020
- Many smart versions of existing product markets
- Few are very high volume; most are small and fragmented
- Key challenge: where to focus?

The Internet of (Very Different) Things

Shipments in 2020 (Millions)

1800
1600
1400
1200
1000
800
600
400
200
0

Connected LED Lamps
Digital set top box
Smart meters
Smoke alarms
Point of sale terminals
Security cameras
Smart household appliances
Toys
Digital signage
Wearable fitness sensors
Vending machines
Parking meters
Bike / activity cameras
Hotel door locks

* Preliminary, September 2013

Wearables

Wearable's are the next generation of computing crossing all vertical markets

Markets evolve and opportunity (units) increase

Year	Market	Units
1980	Minicomputer	10M+ units
1990	PC	100M+ units
2000	Desktop internet	1B+ units
2010	Mobile internet	5B+ units
2020	Wearable/IoT	30B+ units

Devices becoming smaller and thinner

Pebble Watch

Source: TE Connectivity

Wearable Market Growth by Category

World Market for Wearable Technology – By Product ($US million)

Wearables will be a $30B Market by 2018!

Y-axis: 0, 5000, 10000, 15000, 20000, 25000, 30000

X-axis: 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018

Legend:
- Smart Watches
- Smart Glasses
- Smart Clothing
- Sleep Sensors
- Pulse Oximeters
- PERS
- Patches
- Other, Audio Earbuds
- Insulin Pumps
- Imaging Products
- Hearing Aids
- Head-Up Displays
- Hand-Worn Terminals
- Foot Pods & Pedometers
- Fitness & Heart Rate Monitors
- Emotional Measurement
- ECG Monitors (Hospital)
- ECG Monitors (Outpatient)
- Drug Delivery Products
- Defibrillators
- Continuous Glucose Monitors
- Blood Pressure Monitors
- Bluetooth Headsets
- Activity Monitors

Source: IHS, June 2014

Baby Temperature monitoring via wireless

Source: MC10 website

Wearable's Content and Package Requirements

- Common components in all mainstream wearable products:
  - Sensors (1 to 3 sensors)
  - MCU, Data
  - Memory (Flash/DRAM)
  - Connectivity (WiFi, BT, FM, some need Low Power, NFC)
  - Power (Battery)

- Package Attributes:
  - Small, light, flexible, waterproof, connectivity, power, wearable
- Package trends:
  - Market demand growing faster than technology evolution.
  - Current package capabilities are small enough to support most applications in near-term: small body QFN's, WLCSP, SiP.
  - Reliability standards are still being defined.

Technology in Wearable Integration Example

- ASICS, MEMS, & Interconnect Materials
- Product Solutions To End Markets
- Subassembly & Molding
- Program & Test Functionality

Jawbone UP24 Pedometer

- **5 Separate Boards on *Flex* with components**
- **Flex & Rigid,**
- **Micro-Processor Board**
- **Battery Charger Board**
- **Serial Prom Board**
- **Interface Board**
- **MEMS Accelerometer**
- **32Ohm Vibrator**
- **32mAmp/3.7V Lithium Polymer Battery**
- **Hypo-Allergenic Thermal Plastic (TPU) Material**

Source: icintek, Techsearch Wearable's Conference June 2014

Impact on Semiconductor Packaging

World Wide Package Growth *Revenue*

WW Package Growth Revenue

Revenue US $M

$70,000
$60,000
$50,000
$40,000
$30,000
$20,000
$10,000
$0

2013 2014 2015 2016 2017 2018

Others
SOIC
QFN
QFP
WLCSP
PBGA
Bare Chip
FBGA

4.7% Revenue CAGR 2013 - 2018

Gartner "Forecast : Semiconductor Package Unit Demand, Worldwide, 1H14 Update (Sep 2014)"

World Wide Package Growth in *Units*

WW Package Growth M Units

Million Units

300,000
250,000
200,000
150,000
100,000
50,000
0

2013 2014 2015 2016 2017 2018

Others
SOIC
QFN
QFP
WLCSP
PBGA
Bare Chip
FBGA

5.9% Unit CAGR 2013 - 2018

Gartner “Forecast : Semiconductor Package Unit Demand, Worldwide, 1H14 Update (Sep 2014)”

2018 World Wide Package Forecast Rev & Vol

Bubble size relates to Volume

QFN
$2.9B, 70Bu

Bare Chip
$15.1B, 59Bu

WLCSP
$5.6B, 36Bu

SOIC
$1.5B, 30Bu

FBGA
$18B, 30Bu

QFP
$3B, 13Bu

PDIP
$0.2B, 5Bu

Other
$3.6B, 6Bu

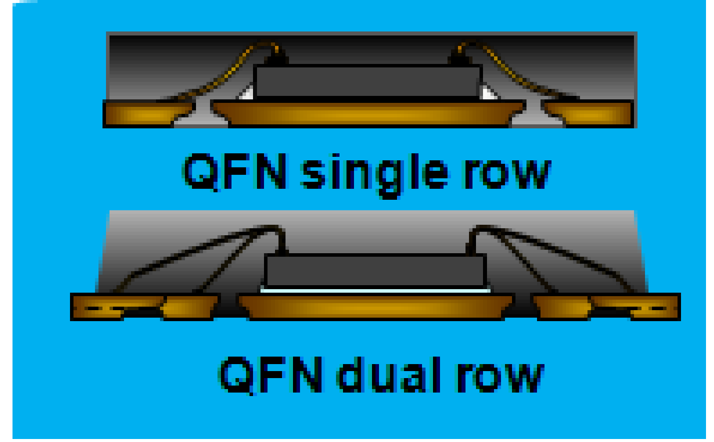
PBGA
$11B, 7.5Bu

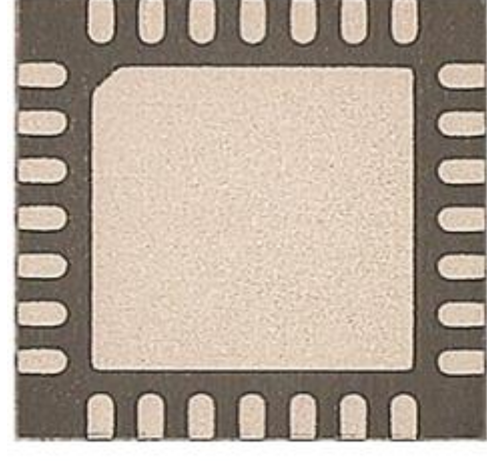
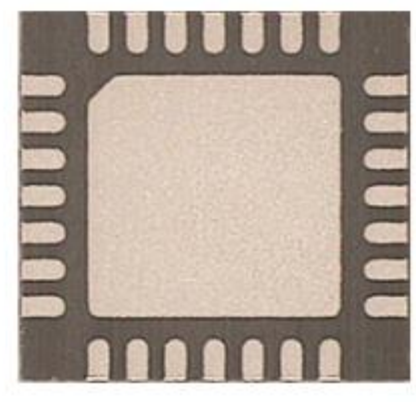
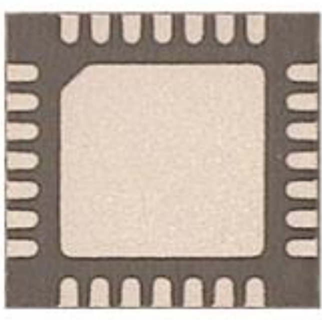
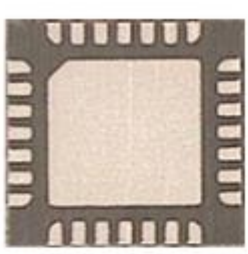
Ceramic CC
$0.7B, 0.5Bu

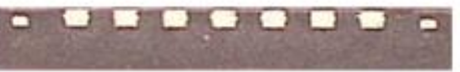
Gartner “Forecast : Semiconductor Package Unit Demand, Worldwide, 1H14 Update (Sep 2014)”

Examples of Key Packages to support IoT

Quad Flat No Lead Package (QFN)





28L QFN 6x6 /0.65mm

28L QFN 5x5 /0.5mm

28L QFN 4x4 /0.4mm

28L UQFN 3x3 /0.3mm

QFN and Its Evolution

Package form factor

QFN

QFN
Fine Pitch
0.4/ 0.35/0.3

LLGA

Dual Row
QFN

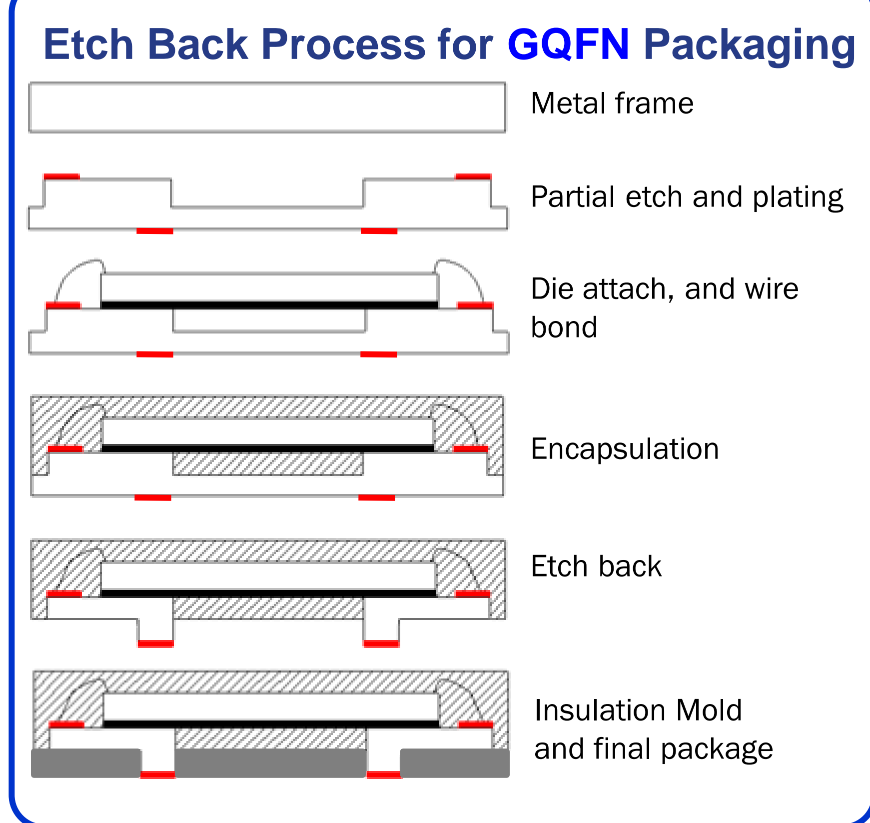
TLA

GQFN

Increasing I/O /
Miniaturization

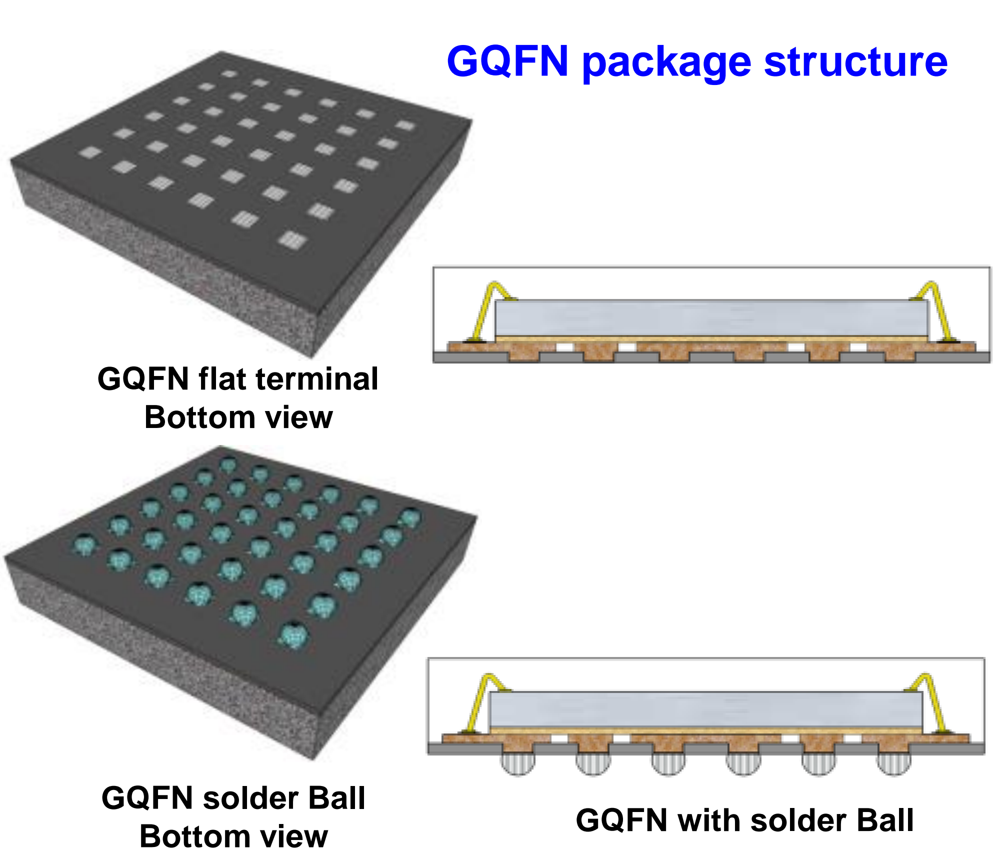
Since 1999 | 2009 | 2010 | 2011 | 2012 | 2015-2017

Area Array QFN (GQFN)



With solder coat / PPF finish

With Solder Ball



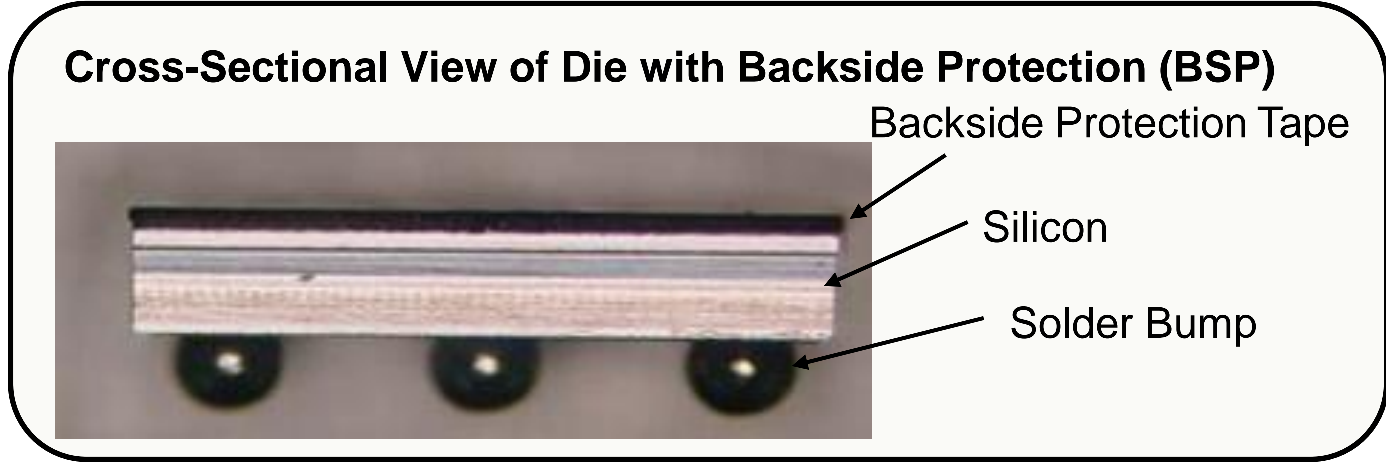
Wafer Level Packaging

WL CSP

Thickness reduction

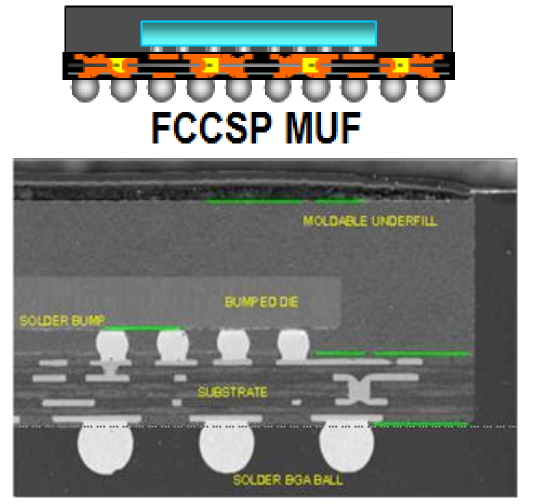
Bumps and RDL

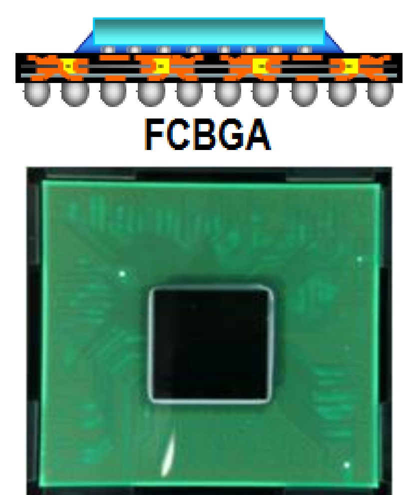
Package Protection

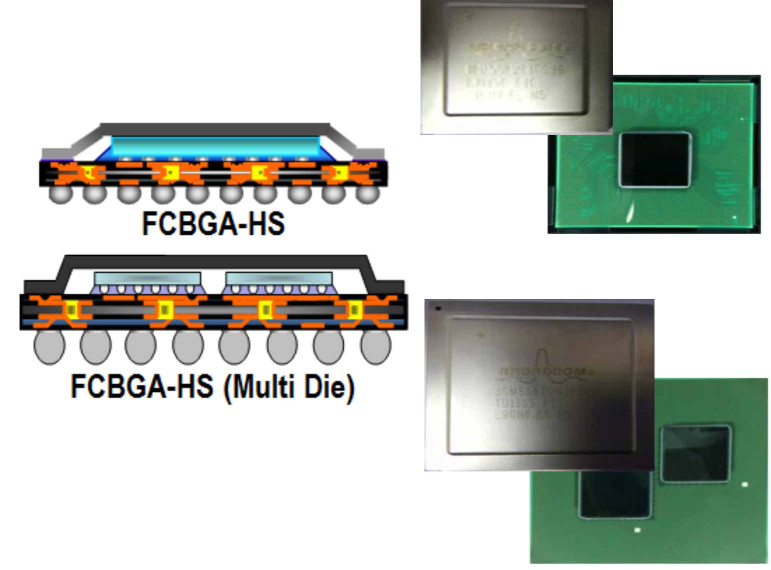


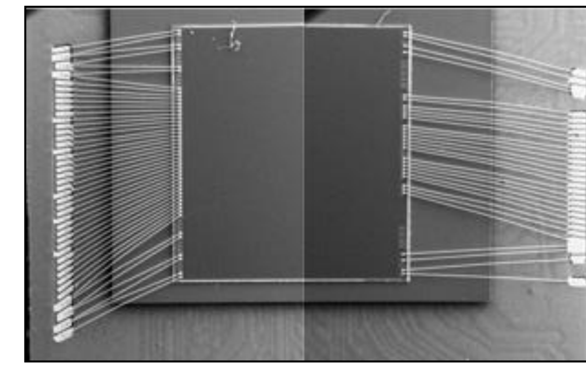
UTAC

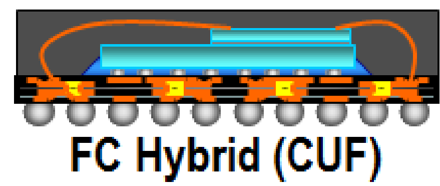
Flip Chip Packages









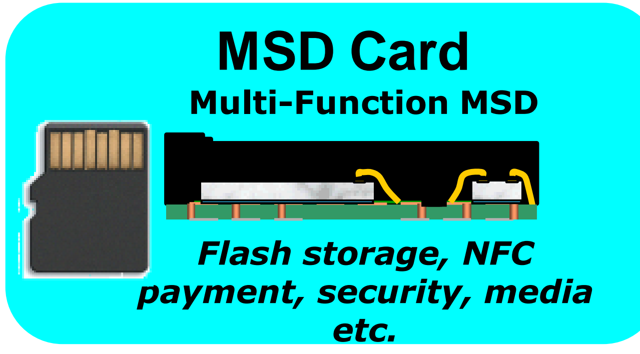


System in Package (SiP)

System-In-Package (SiP)

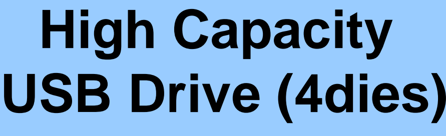
MSD Card

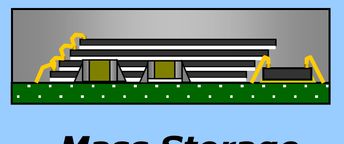
Multi-Function MSD



Flash storage, NFC payment, security, media etc.

High Capacity USB Drive (4dies)





Mass Storage

RF-SIM

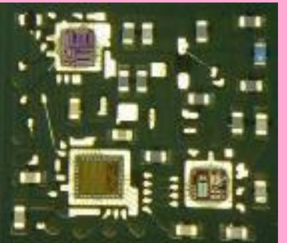
(Multi-Chip Module)

SIM, security, payment etc.(Built-in Antenna)

QFN-SIP

BGA-SIP

LGA-SIP



Thought Of The Day…

“The world is moving so fast these days that the man who says it can't be done is generally interrupted by someone doing it.”

Elbert Hubbard

END

THANK YOU