Semiconductor Industry: How Value Chain is about to Change…

JC Eloy
CEO, YOLE Développement.
Yole Développement

- Yole Développement is a market research and strategy consulting company, founded in 1998 and involved in the following fields:
  - MEMS, including microfluidics
  - Advanced packaging (3D IC, TSV, SoC, WLP…)
  - Power electronics
  - LED & HB LED
  - Compound semiconductor business (SiC, GaN, AlN, ZnO, Thick SOI…) at substrate and device level
  - Photovoltaic, from equipment and materials to cell business

- Our research is performed by in-house personnel conducting open-ended discussion based interviews.
  - 20 full time analysts with technical and marketing degrees
  - Primary research includes over 2,500 interviews annually

- Our customers’ base and perspectives are global.
Our Global Presence & Activity

30% of our business is in North America

Yole Inc.  → perkins@yole.fr

40% of our business is in EU Countries

Yole Paris  → eloy@yole.fr

30% of our business is in Asia

Yole KK.  → katano@yole.fr

Yole Développement Lyon (HQ).

30% of our business is in Asia
# Some of Our Customers

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<td>TOPCON</td>
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</table>
| Lam Research | SEMI | STS | Fujitsu | ABB |}

Some of Our Customers:

- Booz Allen Hamilton
- Bain Capital
- Applied Materials
- Dalsa Technology
- Air Liquide
- SSL
- STS
- Fujitsu
- TOPCON
- TEL
- EVG
- SSL
- STS

**R&D Organizations**

- Scottish Enterprise
- SMH Capital
- Applied Ventures
- Chipworks
- ETRI
- ETRI
- imec
- Fraunhofer Institute
- KOPTI
- KIMM
- Samsung
- HSG
- IMI
- Samsung
- HSG
- IMI

**Suppliers (equipment, wafers, materials)**

- Applied Materials
- Dalsa Technology
- Air Liquide
- TEL
- SSL
- STS
- Fujitsu
- TOPCON
- TEL
- EVG
- SSL
- STS

**Component manufacturers**

- Infineon
- e2v
- microIninity
- Fujitsu
- TOPCON
- TEL
- SSL
- STS
- Fujitsu
- TOPCON
- TEL
- EVG
- SSL
- STS

**Integrators, system manufacturers and end users**

- Continental
- Ebara
- Seagate
- Topcon
- Toyota
- ABB
- Continental
- Ebara
- Seagate
- Topcon
- Toyota
- ABB
- OLYMPUS
- NIKON
- MITSUBISHI PRECISION
- BAE SYSTEMS
- Siemens VDO
- Panasonic
- ALSTOM
- Samsung
- BRIDGESTONE
- DENSO
- Sony
Custom Analysis Services

- **Market research and marketing analysis**
  - Identification of new applications and markets
  - Set-up of market segmentation
  - Proposal of marketing and action plans

- **Strategic analysis**
  - Analysis of positioning to create value
  - Development of action plans to improve company performance
  - Support in implementation and fund raising

- **Technology evaluation**
  - Analysis of technical areas and definition of technology strategy
  - Process cost analysis and cost comparison
  - Development of product and technology roadmap

- **Specific services for investors by Yole Finance**
  - Evaluation and analysis of business plans
  - Evaluation of production infrastructure
  - Expertise and due diligence before M&A
    - Company, market and technology expertise
    - Strategy, marketing and technical due diligence
About Yole’s Advanced Packaging Analysts

Jean-Marc Yannou
– Jean-Marc joined Yole Développement as technology and market expert in the fields of advanced packaging and Integrated Passive Devices. He has 15-years of experience in the semiconductor industry. He worked for Texas Instruments and Philips (then NXP semiconductors) where he served as “Innovation Manager” for System-in-Package technologies.

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Phil Garrou
– Phil recently joined Yole Développement forces as senior technical advisor in the fields of advanced packaging. Phil as more than 20 years extensive experiences in the semiconductor industry where he mainly served as global marketing manager for DOW Chemical’s BCB polymer business.

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Jerome Baron
– Jerome is leading the MEMS & Advanced Packaging market research at Yole Developpement. He has been following the 3D packaging market evolution since its early beginnings at device, equipment and material levels. He was granted a Master of Science degree in Nanotechnologies from the National Institute of Applied Sciences in Lyon, France.

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Christophe Zinck
– Christophe joined Yole Developpement after several positions in the wafer fab and packaging environments of CEA-Leti, STMicroelectronics and then Triquint Semiconductor, where he was lead manager for flip-chip and wafer-level-packaging technologies implementation.

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### Some of Our Customers

#### Financial investors & industry advocates
- SEMI
- DARPA
- Bain Capital
- Booz Allen Hamilton
- Applied Materials
- EVG
- Dalsa
- Air Liquide
- ASML
- Lam Research
- Multies
- Despatch Industries
- ASET
- OMD
- Saas
- Boyce
- Exploit Technologies
- SCHOTT
- PVA TePla
- Corning (formerly Optical Products Division)
- Nippon Steel
- Micron
- Samsung
- Saint-Gobain
- Rohm
- Rohm
- Intel

#### Suppliers (equipment, wafers, materials)
- Aimec
- Infineon
- E2V
- Analog Devices
- MicroParts
- Freescale
- Topcon
- Sharp
- Bosch
- Toshiba
- Siemens
- AMI
- Kyocera
- NXP
- Honeywell
- Qualcomm
- STMicroelectronics
- VTI Technologies
- Canon
- Sumitomo Metals
-Intel
- Sanoh
- Samsung
- OMM
- Texas Instruments

#### Component manufacturers
- Philips
- Analogue Devices
- MicroParts
- FreeScale
- Labs of America
- Sharp
- Bosch
- Toshiba
- Siemens
- AMI
- Kyocera
- NXP
- Honeywell
- Qualcomm
- STMicroelectronics
- VTI Technologies
- Canon
- Sumitomo Metals

#### Integrators, system manufacturers and end users
- Continental
- Siemens
- Ebara
- Seagate
- Sony
- Ebara
- Toshiba
- Mitsubishi
- Daikin
- Toyota
- ABB
- Olimpus
- France Telecom
- Mitsubishi Precision
- Northrop Grumman
- BAE Systems
- Siemens VDO
- Panasonic
- Alstom
- GE
- Boeing
- IBM
- LG
- Michelin
- Bridgestone
- Sony
- Denso
- YokoKama
- Lumet Technologies
- Yorozuya
- Samsung

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R&D Organizations:
- ETRI
- Leti
- imec
- CMC
- KIMM
- IMI

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Advanced packaging reports from YOLE
Advanced Packaging evolutions...
Overall package growth CAGR ~ 9%

- Overall package growth CAGR ~ 9%
- WLP & QFN packages are forecasted to experience > 20% CAGR
IC Package units growth breakdown

IC Package unit growth breakdown (*Bunits*)

- **QFN** packages are forecasted to experience > 20% CAGR
- **WLP** (Fan-in WLCSP, Fan-Out WLP), Embedded package and 3D interposer packages are forecasted to enjoy the highest growth with ~ 30% CAGR
Packaging Supply & Value Chain ...

- Wafer Fab (Front-End) / Assembly & Testing (Back End) / PCB Mounting: 
  ➔ A mix of captive manufacturing and outsourcing!
… Growing in the “Mid-end”

- Wafer Fab (Front-End) / Assembly & Testing (Back End) / PCB Mounting:
  → A mix of captive manufacturing and outsourcing!
“Mid-end” Infrastructure Outlook as of 2009

- Increasing value is going to the “Mid-end” of the IC value chain
- WLP is the main driver today. 3D TSV and Embedded component demand is burgeoning...

Value flow
- WLP ~ $550M
- 3D TSV ~ $300M
- ~ $0.8B

Values
- ~ $250B
- ~ $25B
- ~ $40B

Years
- 2000 - 2015
- 2005 - 2020
- 2010 - 2020

Emerging
- ~ $0B (emerging)
We estimate that by 2013, the “Mid-end” infrastructure will generate about 10% of total Packaging BE activity (captive + outsourced) by then!
We estimate that by 2016, the “Mid-end” infrastructure will generate about 20% of total Packaging BE activity (captive + outsourced) by then. And this is just the beginning…
Advanced Packaging evolutions

PANEL / Wafer-Scale-Packaging Platforms

Wafer-Level
Electrical Redistribution
- WL-CSP ‘Fan-in’
- FOWLP ‘Fan-Out’

Wafer-Level
Interface / Encapsulation
- MEMS & Sensors Capping
- LED & Sensors Optics
- Systems with Fluidic

Flip-chip & Wafer-Level
Stacking / Integration
- Embedded IC in PCB / laminate
- 3D IC & TSV
- Glass / Silicon interposers
- Flip-chip BGA

Courtesy of DALSA

LED & Sensors
Optics

3D IC & TSV

Glass / Silicon interposers

Flip-chip
BGA

Systems with Fluidic

MEMS & Sensors Capping
FOCUS ON FAN OUT WLP AND EMBEDDED DIE.
Concepts of FOWLP / Chip Embedding in PCB

- Two types of Embedded Wafer-level-packages are emerging
  - FOWLP is based on a reconfigured molded wafer infrastructure
  - Embedded die is based on a PCB type of Panel infrastructure

- FOWLP 1st generation
  - FO MCP
  - FO PoP
  - FO SiP

- Embedded die
  - Single chip
  - Embedded MCP
  - Embedded PoP
  - Embedded SiP
Supply Chain for Embedded Chip Packaging

WLP preparation
- Cu pads + Wafer Test + Wafer Thinning / Polishing

BE steps
- Marking, Dicing, inspection, Tape & Reel

Chip Embedding process
- ASE (TW)
- SPIL (TW)
- Amkor (KR)
- StatsChipPAC (SG)
- Flip-Chip International (US)
- UTAC / NEPES (SG / KR)
- Casio Micronics (JP)

Balling & Board level Test
- Compass technology (China)
- Schweizer Electronic (GE)
- Epcos - TDK (GE / JP) pilot line ready
- CireTec (FR)
- Dyconex (Swiss) pilot line ready
- AT&S (AT) production line by Q3-2010
- Imbera / Daeduck (FI / KR) production line by Q2-2010
- SEMCO (KR) production line in qualification
- Ibiden (JP)
- NEC (JP)
- CMK (JP)
- NEC Toppan (JP)
- Taiyo Yuden (JP)
- OKI Printed Circuits (JP)
- Clover Electronics (JP)
- DNP (JP)

SMT / SiP Module integrators
- ADI
- Qualcomm
- VTI
- Continental
- STMicro
- Thales
-ams
- Bosch
- Infineon
- TI
- NXP
- NSC
- CSR
- Dialog Semi
- Maxim IC
- Denso
- Samsung
- STEricsson
- Toshiba
- Renesas / NEC
- Murata
- Casio
- Panasonic
- Fujitsu
- IPS (US)
- Sony

OEMs
- Seagate
- Medtronic
- Continental
- Toyota
- Seurin
- Nokia
- LG
- Panasonic
- Motorola
- Samsung
- Samsung
Fan-Out WLP Emerging Supply Chain

**FOWLP IP**

- **CEA - Leti** (R&D)
- **3DPlus** (WDOD)
- **Freescale** (RCP)
- **Infineon** (eWLB 1st generation)
- **ST / StatsChipPAC / Infineon** (eWLB 2nd generation)
- **NTHU** (PLP)
- **ITRI**
- **ACE**
- **Ibiden**
- **Internal development of FOWLP IP?**

**FOWLP Packaging, Assembly & Test services**

- **3DPlus** (France, WDOD line)
- **Tong Hsing** (TW, 200mm RCP and WDOD)
- **Freescale** (Austin - US, 200mm pilot line)
- **NEPES / UTAC** (SG, 300mm RCP production line in qualification)
- **SPIL / PPT** (Taiwan, 300mm eWLB line in qualification)
- **ASE** (Taiwan, 200mm eWLB production line since 2009)
- **NANIUM** (Portugal, 300mm eWLB production line in qualification)
- **StatsChipPAC** (Singapore, 200/300mm eWLB production lines)
- **Infineon** (Regensburg, eWLB 200mm pilot line)
- **STMicro** (Singapore & Shenzhen, future plan for eWLB 2nd gen.)
- **King Dragon International** (Taiwan, 400x400mm square PANEL)
- **Aptos / ACE / KYEC** (Taiwan, 200mm / 300mm / PANEL line)

**Customers / SiP integrators**

- **3DPlus** (WDOD)
- **NXP**
- **ADI**
- **Freescale**
- **Intel?**
- **CSR**
- **Qualcomm**
- **STEricsson**
- **Wolfson**
- **Dialog Semi**
- **Infineon**
- **STMicro**
- **Broadcom**
- **Texas Instrument?**
- **Mediatek?**
- **SST**

**OEM**

- **Medtronic**
- **Thales**
- **Motorola**
- **LGE**
- **Nokia**
- **Sony-Ericsson**
- **Samsung**
- **NEC / Micron / Elpida / Hynix** (Logic & Memory)
- **OptoPAC, Anteryon, STMicro** (WLOptics / CIS molding)
**2010 FOWLP Production Market Shares** (based on wafer capacity)

### 200mm - FO WLP production

2010 market share

- **ASE (TW)**: 110,000 wafers (63%)
- **STATschippaC (SG)**: 5,000 wafers
- **Freescale (US)**: 5,000 wafers
- **Infineon (GE)**: 7,000 wafers
- **Amkor**: 10,000 wafers (6%)
- **ACE (TW)**: 35,000 wafers (22%)

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### 300mm - FO WLP production

2010 market share

- **STATschippaC (SG)**: 75,000 wafers (83%)
- **NANIUM (PT)**: 15,000 wafers (17%)

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### Status of 200/300mm FOWLP commercialization as of Q2-2010

- ASE (TW) and ACE (TW) are clearly leading the volume for 200mm FOWLP wafer production. Amkor is set to ramp-up in production this year. StatsChipPAC (Singapore), Freescale (Austin), and Infineon (Regensburg, Germany) also have installed 200mm capacities but these lines are small pilot lines dedicated to small production volumes for prototyping and packaging R&D only (see ‘supply chain’ chapter for more info).
- StatsChipPAC (SG) and NANIUM (Portugal) invested more than $130M in FOWLP equipment and infrastructure since this year both players have been qualified by Infineon to produce eWLB on 300mm.
FOCUS ON 3D TSV.
Some Early Product Sampling or in Production with TSV

- Avago's FBAR & Power amplifiers devices
- InvenSense 3-axis MEMS gyroscope
- SiTime's MEMS oscillator
- VTI 3-axis MEMS accelerometer
- VisEra's HB-LED silicon Module
- Omivision CMOS image sensor
- STMicro CMOS imager & inertial MEMS sensors
- Toshiba CMOS image sensor
- IDEX's fingerprint sensor
- Epcos / Sonion MEMS Silicon-microphone
- Toshiba CMOS image sensor
Who is the Best 3D IC Builder?

IDMs, MEMS manufacturers, wafer foundry, packaging houses and OSATs are all poised to take on more value in this new era, but at the same time new investment and learning will be required for ALL of those players!
FOCUS ON SILICON AND GLASS INTERPOSER.
3D silicon interposer structure & definitions

*Generic Cross-section drawing*

- **Front-side BEOL**
  - Active or Passive Component (optional)
  - BEOL (Back End of Line)
- **Back-side RDL**
  - RDL (Routing Layer)
- **Substrate** (Glass or Silicon)
  - TSV (Through Silicon Via)
- **UBM** (under Bump Metallurgy)
  - Metal (Al or AlSiCu or Cu or W)
- **ILD** (Inter Layer Dielectric, SiO2 or Si3N4 or polymer…)
- **Dielectric passivation** (Polyimide, BCB, epoxy, AL-X)
- **Fine-pitch (50µm) micro bumps**
- **Bumps or Copper pillars (100-200µm pitch)**

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### 3D silicon/glass interposers

#### Who is doing what?

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<th>TSV/TGV making</th>
<th>RDL</th>
<th>test of interposer</th>
<th>Bumping</th>
<th>Packaging and assembly</th>
<th>final test</th>
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<td>Glass substrate makers</td>
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<td>IC wafer foundry</td>
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First conclusions

- ‘Mid-end’ business ~ 20% of BE packager revenues by 2016
  - Driver for these players is to sustain growth & preserve margins in this cost competitive market
  - Challenge: annual R&D investment budget usually low

- ‘Mid-end’ business ~ 2% of FE semiconductor revenues by 2016 only
  - Not driven by revenues generated!
  - Rather interested by the potential behind this integration:
    - In order to package everything by themselves and not rely on subcontractors as packaging is now becoming increasingly strategic to control!
    - To climb in the electronic value chain by integrating more additional functions and moving to “system” integration

- High interest for 3D from system integrator companies in medical (Medtronic, SJM…) and automotive areas (Honda, Toyota, Denso, Bosch…)
  - 3D IC integration with TSV implies possible changes in the electronic value chain: could OEMs & system integrator players become the next “SOC makers”?
For more information ...

Take a look at our websites

www.i-micronews.fr

Please make a stop at Yole booth: N° C2135

Feel free to give me your business card to receive the electronic copy of my slides.