Advanced Packaging Techniques as enablers for the Health IoT ecosystem

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Presented January 25, 2016 to the SCV-CPMT Chapter

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- IoT -> Health IoT
- Devices, Services, Specifics to Health
- Main challenges @ device level
- Packaging Technology Solutions
- Examples
- Outlook

Internet of Things

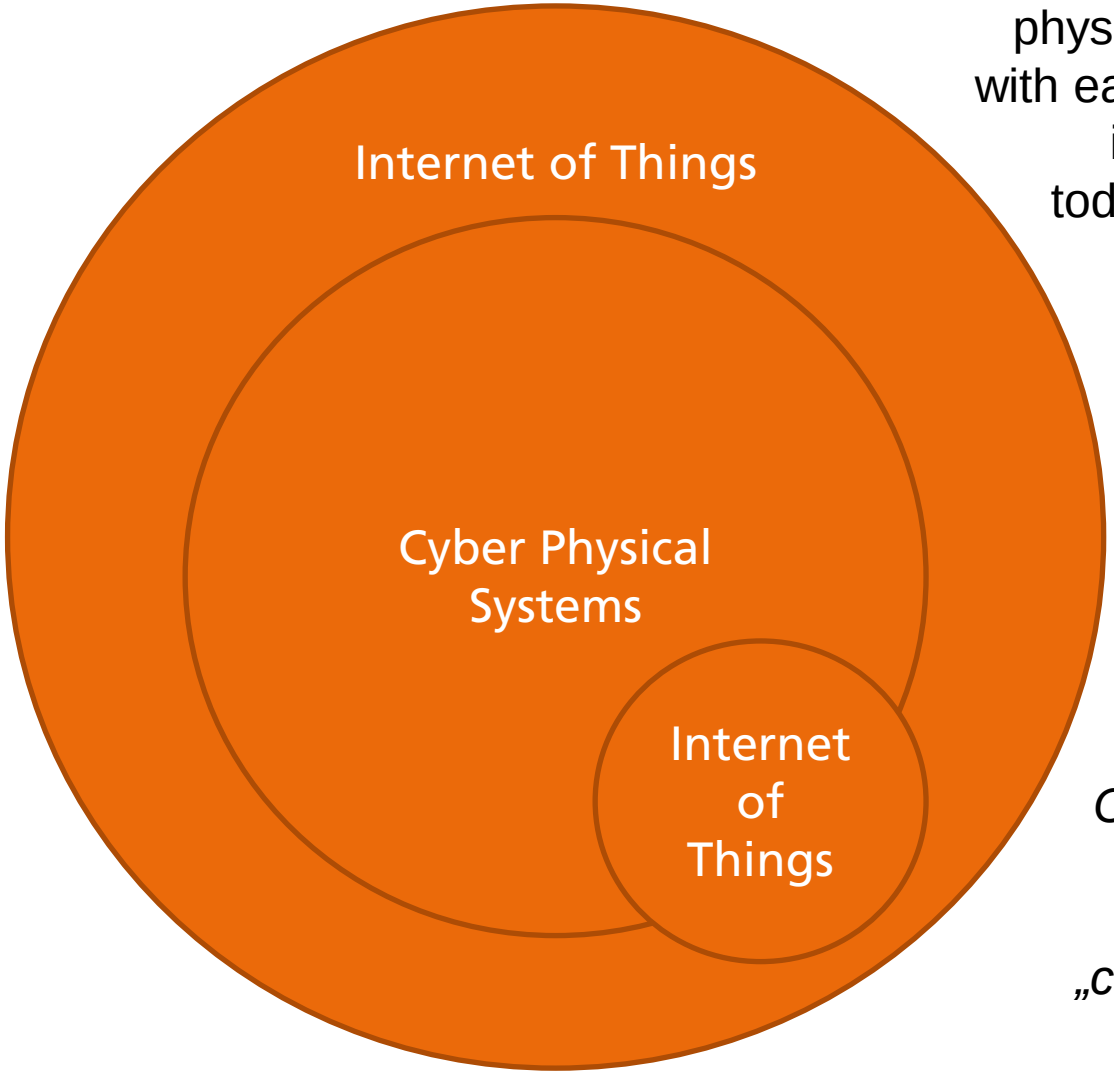
- Coined already in 1999, driven by the advent of electronic ID of devices
- Network enabled connection of objects („things“) with a multitude of other objects
- Allowing for multi-domain data transfer, interpretation and interfacing to both other objects and humans
- Autonomous (re)action of IoT objects based on connected information
- Paradigm Change from passive „Send/Receive“ towards active „Query/React“

„This is me!“ „This is really me!“ „Yes, it´s really you!“

- Needs: Unique ID, safe and secure data provisioning, trusted peer environment, hierarchy independent functions, regardless of protocol, domain and application

„Here´s what I can offer, what do you need?“

Internet of Things



While originally, the IoT adresses physical objects exchanging information with each other and CPS offers real-world interaction of such IoT subsystems, today´s notion of IoT encompasses as a „network of networks“ with non-discriminatory data exchange and real-world interaction

Smart Home Control with Grid Level Communication

Car2Car sensor communication and weather forecast

„cloud assisted gardening“ (MIT)

Health IoT

- IoT dedicated to health and well being
- „Wearables“ as catalyst but wearables are NOT the Health IoT!
- Connecting medical grade diagnostics devices capturing individual´s data …
- …merging with patient and population history data
- …merging with non-health meta-information (ambient data, smart home data, flu outbreak map, …)
- … building a patient individualized (and montiored!) therapy schedule
- … retrieving outcome information for further routine improvement
- …using data retrieval and interpretation tools to extract invisible information

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Who talks to whom?

Family

Patient

Personal Devices

Doctor

Medical Care Devices

Infrastructure Embedded Devices

Clinics

Caregivers

Research Databases

Reimbursement Systems

National Security Databases

Patient Expectations

Belli
From Bloom.
A medical-grade smart device designed for women

Unobtrusive
Non stigmatizing
24/7 availability
Service and support

Device -> Patient -> „all well with me?“

Device -> Doctor - > „all well with the patient?“

Device -> Family -> „Guys, I am well!“

Device -> Assisting Ambient -> „I need a stress redux“

Doctor Expectations

Device -> Doctor

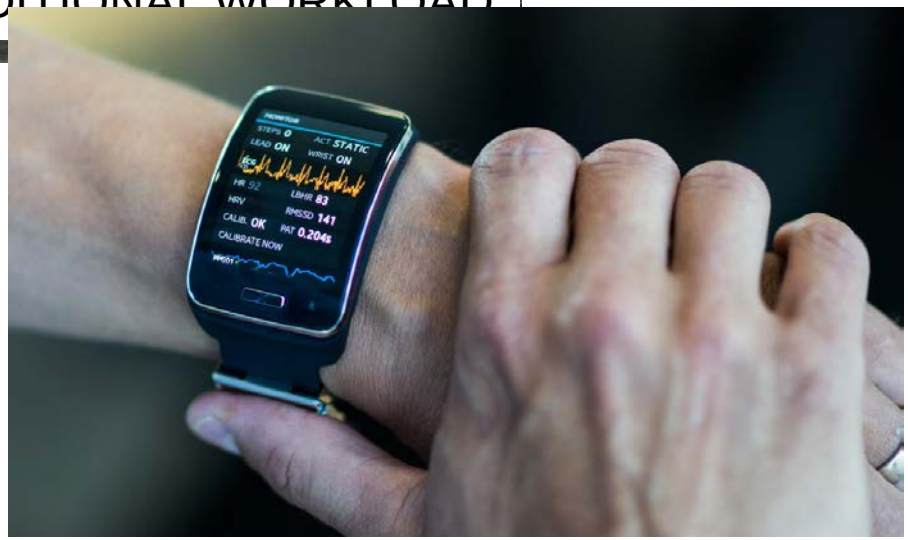
Pre-Evaluation System (PES) -> Doctor

Doctor -> Clinical Documentation System

Device and PES -> Reimbursement Documents

Doctor -> Patient
Device / Doctor -> Electronic Health Record (EHR)

NO ADDITIONAL WORKLOAD



Monitoring on Request
Info on Triggerevents
Assistance on Documentation

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Hospital Expectations

Streamlined Processes

Happy Doctors

Cured Patients

No queuing, less stress to all

Device –> PES
Device -> Reimbursement Doc
Doctor/Device -> Clinical Documentation System + EHR
Device -> Scheduling and preventive action triggering
….

Reimbursers Perspective

Lower Cost

Lower Cost

Lower Cost

Preventive Care
Lifestyle adjustments
Tariff adaption

Device -> Data Mining System and
Individualized Assessment

What kind of devices are we talking of…

Personal Devices

- Augmented state of the art
  - Holter ECG
  - BIA Body Impedance Analysis
  - Handheld Glucose Meter
  - SpO2
  - Quick, Trial, HbO
  - Medication Bottles
  - Rehab/Training Devices
  - Blood Pressure Monitor BPM
- New devices
  - Connected Medication Blisters
  - „Wearables“
  - „Earables“
  - Body worn spirometry
  - Gait Monitors
- Future devices
  - Glucose Monitoring Lens („Google Lens“)
  - Eye Pressure Contact Lens or IOL
  - Implanted Drug Dosing Chip

Medical Care Devices

- Augmented SoA
  - Blood Testing Lab
  - Clinical Monitoring Devices
  - Bed Side Therapeutic Systems (CPAP, Drug Dosing, O2, ..)
  - Implants
- New devices
  - PoCD
  - Vein Mapping
  - Medication Monitors
  - Insuline Patch Pump
  - …
- Future devices
  - Temporary Implants
  - Enhancer Implants
  - Electronic Dosing Patches

Infrastructure Embedded Devices

- Oxygenators
- CT/MRI/SPECT/PES
- Fixed Assets
- Home Appliances
- Ambient Assisted Living Elements
- …

Health IoT – Safety and Security is Mandatory

- While in a „connected world“, IoT, likely 90+% of the devices will not have a dramatic impact if data failure/manipulation occurs, Health IoT MUST adopt right from the beginning safety/security concepts.
- Safety/Security mandated by legislation and prerequisite for customer/patient acceptance
  - Medical Devices governed by respective legislation
  - Personal Devices still in a „gray area“
- Data ownership is also a crucial aspect
  - Medical Device Data in debate!
  - Personal Device Data in debate!

OPEN but SAFE and SECURE Data concepts are will be a tipping aspect for a Health IoT success

Health IoT - Connectivity

- Devices will have –dependent on their use cases- different kinds of connectivity options (BAN, PAN, LAN, WAN), protocols and safety requirements
- Connectivity may result in a local, „fog“ or „cloud“ data processing and (re-)action, depending on preset, pre-learned or derived triggers

- „IFTTT“ approach with a human programmed connection cannot cope with the world of tomorrow…

Elderly has measured previously low blood glucose,
has not taken her medication,
home indicates non-moving presence in living room
->
Monitoring call,
emergency call,
unlock door upon arrival,
flash ceiling light for presence indication

Health IoT Needs and Deeds

- While Health IoT is from a ecosystem and IT point of view still in its infancy, the necessary hardware technology is not

- Sensors ✓
- Safety/Security Features ✓
- Calculating Power ✓
- Dynamically Configurable Memory (Hacking) ✓
- Connectivity ✓
- Energy Supply ✓

Image: TI

Good job…..

… but advanced packaging can do better!

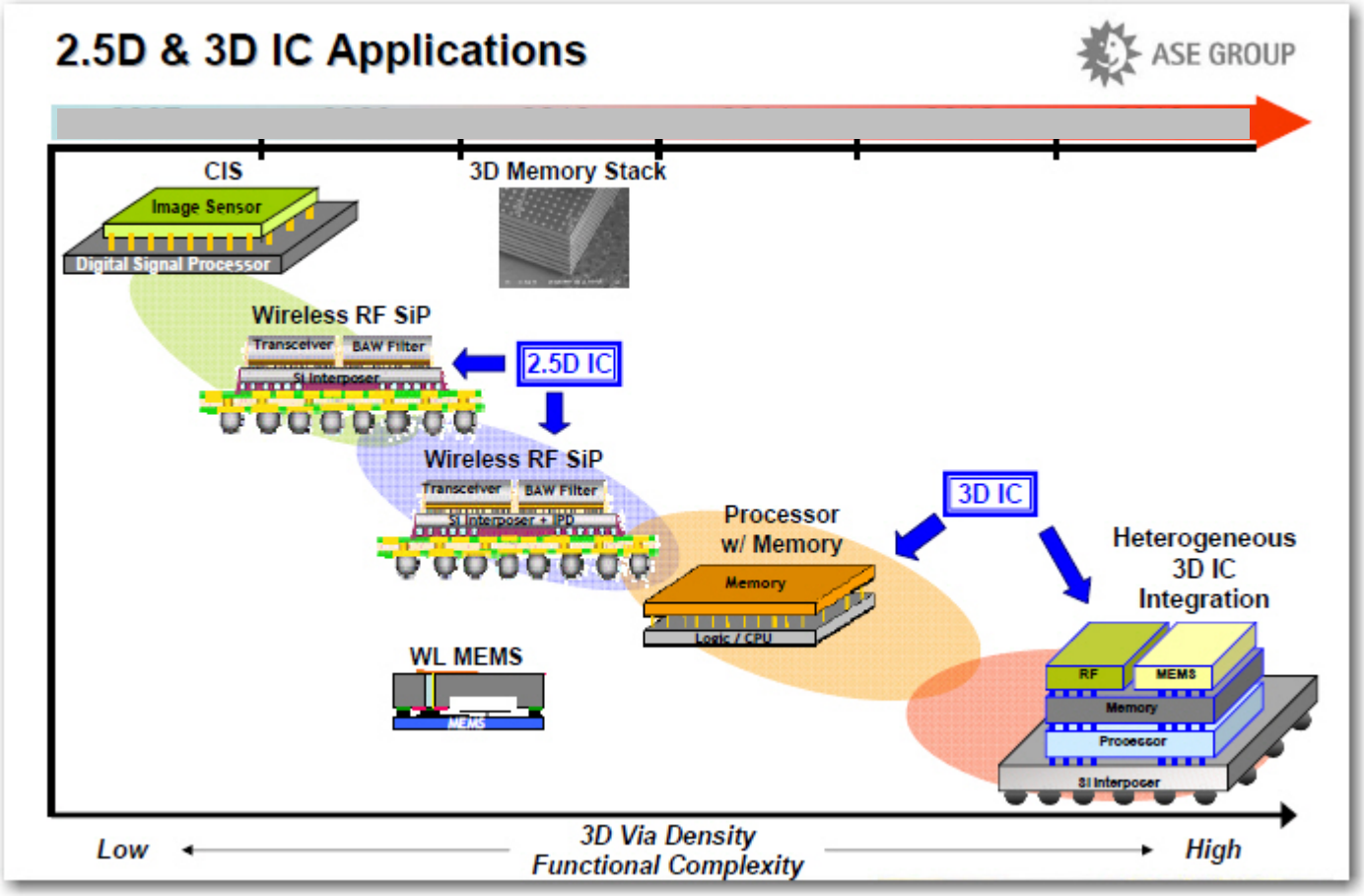
Packaging Technologies for Personal Devices in an Health IoT EcoSystem are driven by the need to

Smaller form factor	➡ High Density Packaging
Higher Integration	➡ Minimum Material Usage/Waste
Modularity	➡ Modular Assembly Concepts
Co-Design of Function, Component Packaging, SystemPackaging and User/Application-Centric Design	➡ Modular Design, Hardware Submodules, „Building Blocks“
Longer Battery Stamina	➡ Integrated Batteries/Charging Concepts
Re-Configurable Wireless	➡ Novel Antenna Concepts, UWB circuits
Re-Configurable Memory	➡ Nonvolatile low power memory modules

Packaging Technologies for Personal Devices in an Health IoT EcoSystem are driven by the need to

Smaller form factor	➡ Ubiquitous Deployability
Higher Integration	➡ Ressource Efficiency
Modularity	➡ Improved Fabrication and Cost
Co-Design of Function, Component Packaging, SystemPackaging and User/Application-Centric Design	➡ Adaptability to use case
Longer Battery Stamina	➡ Maintenance/Usability
Re-Configurable Wireless	➡ Adaptability to infrastructure
Re-Configurable Memory	➡ Adaptability to required tasks

System in Package may drive the way…



… and both wafer and backend will contribute!

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Application Specific Modularity

- Choose your sensors
- Choose your µC
- Choose your Crypto
- Choose your energy scenario
- Choose yor wireless

Proper SiP strategy allows for lot size 1…millions

Application Specific Modularity

- Choose your sensors
- Choose your µC
- Choose your Crypto
- Choose your energy scenario
- Choose yor wireless

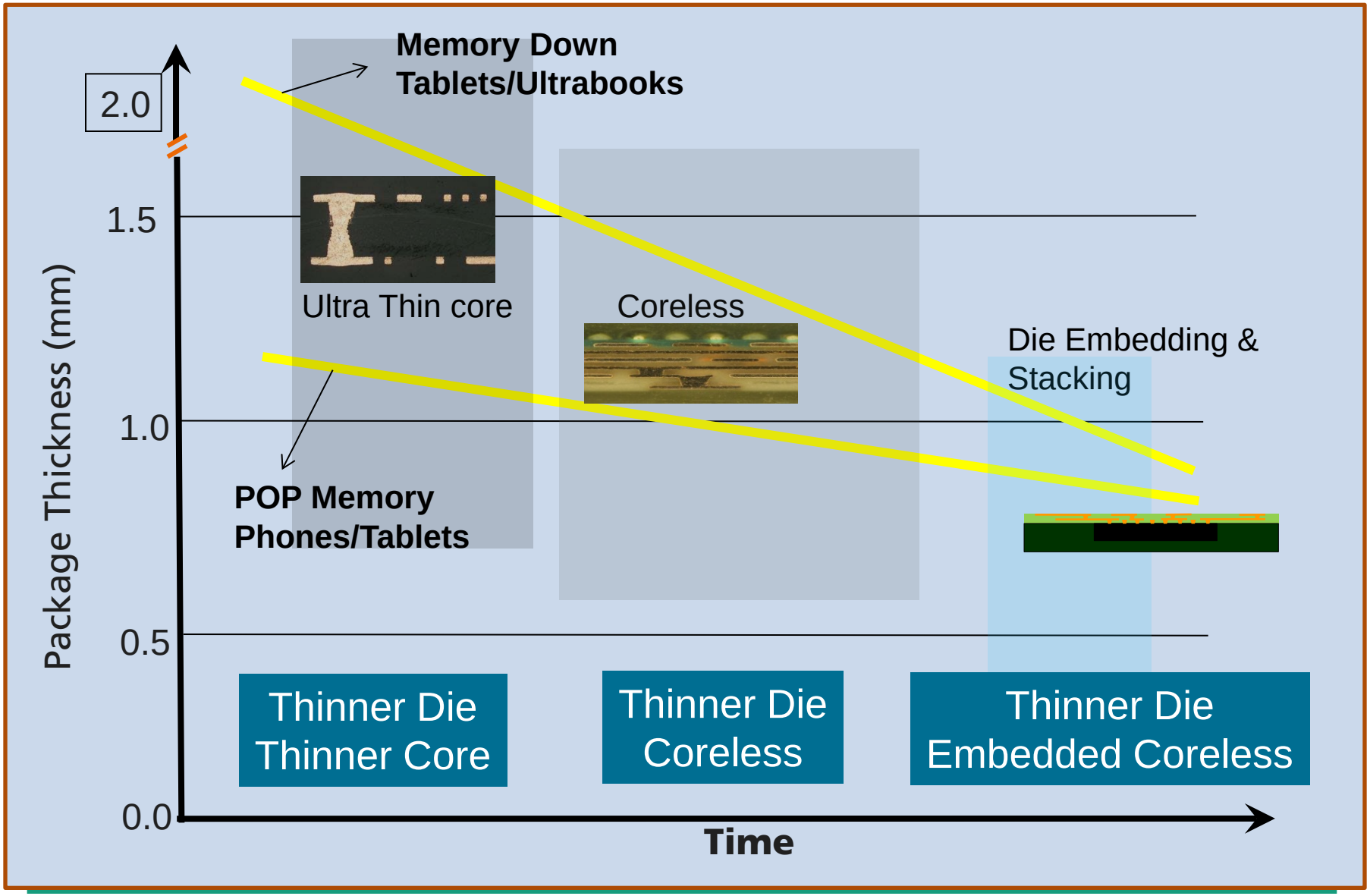
Proper SiP strategy allows for low cost at high functionality, small form factor and optimal modularity

Packaging Options on the way towards ubiquitous IoT

- Mold Array Package
- Package in Package
- Package on Package
- Fan Out Wafer Level Package
- Panel Level Package

- Stacked Chips w/ Wirebond
- Stacked Chips with TSV and µ-Bumps
- Stacked Chips via Chip First Technology

Package Thickness & Technology Trends



Source: Intel

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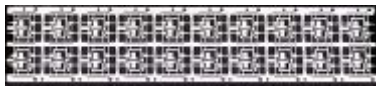
Chip Embedding – Production Format Comparison

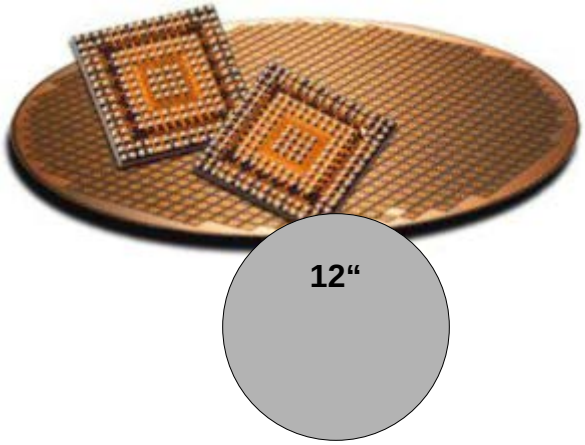
Manufacturing on leadframes



~ 155 cm²

- **Leadframe technology**
- Established process
- many process options
- cost optimised

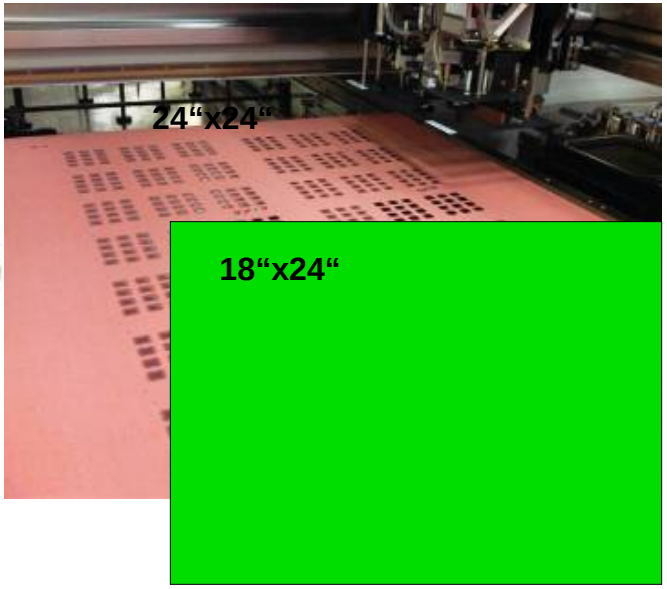
Fan-out wafer-level package



~ 730 cm²

- **thin film technology**
- fast production ramp-up
- today high I/O chips
- 3D under development

Chip embedding in substrates



~ 2790 cm²

- **PCB technology**
- begin of production
- today low I/O chips
- intrinsic 3D and power capability

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FanOut Wafer Level Packaging: FO-WLP

- Single function device packaging at small footprint with PCB compatible I/O pitch
- Multi function device combination at smallest footprint with intrapackage interconnect and PCB compatible external I/O pitch

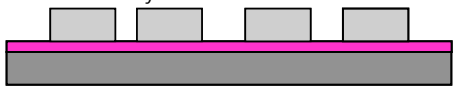
- Reconfiguring of wafer sized platform (mechanical and/or electrical)
- Overmolding
- w/ w/o balling
- Dicing

FoWLP Process Flow Options

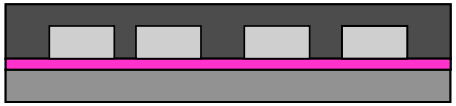
Mold first

Apply thermal release tape on carrier

Die assembly on carrier

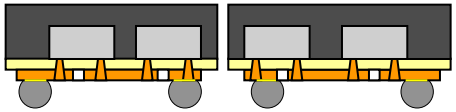


Wafer overmolding



Carrier release

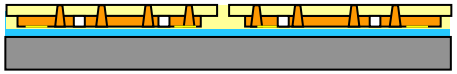
RDL (e.g. thin film, PCB based, …), balling, singulation



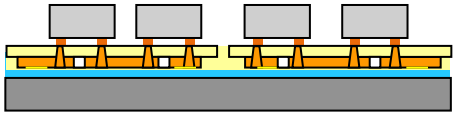
RDL first

Apply release layer on carrier

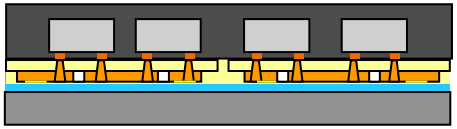
RDL (e.g. thin film, PCB based, …)



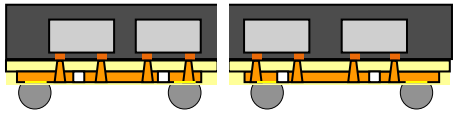
Die assembly on carrier

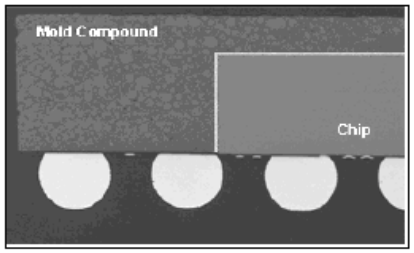


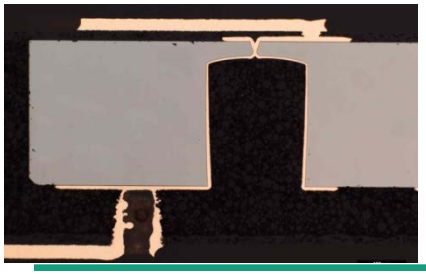
Wafer overmolding

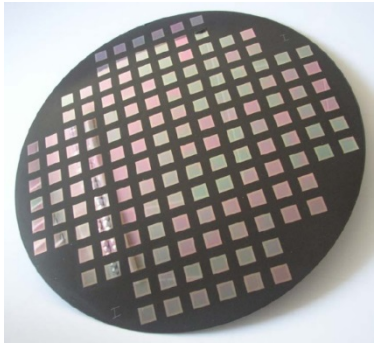


Carrier release, balling, singulation









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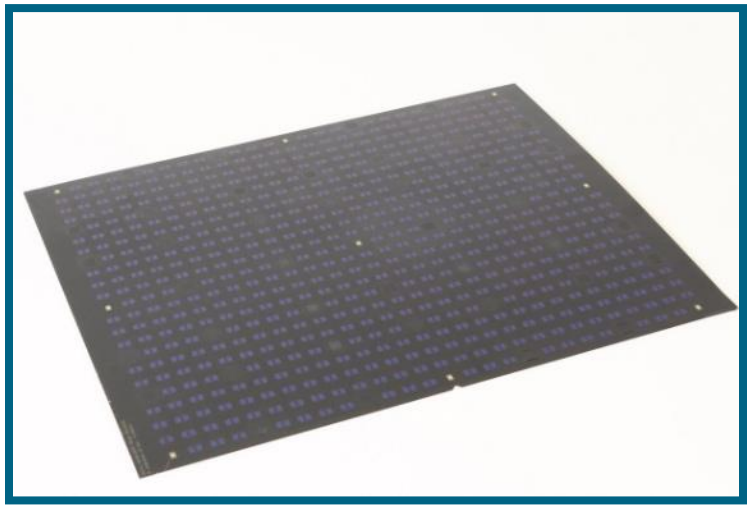
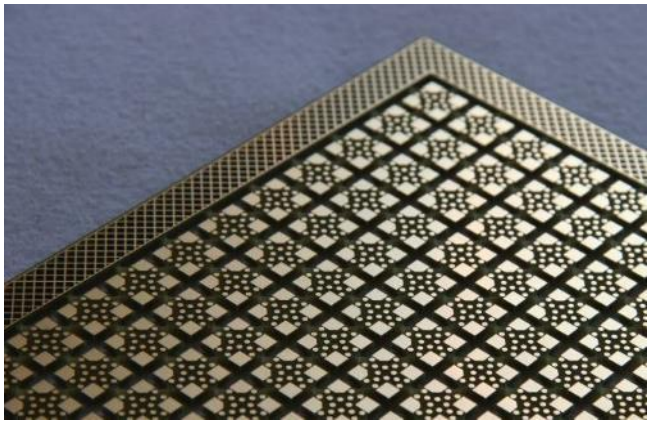
Panel Level Packaging: PLP

Panel-Size FO WLP



- Large-area molding 18" x 24"
- Through mold vias for 3D
- Interconnects using PCB materials & technology
- mold embedding of sensors

PCB Embedding - ECPLP



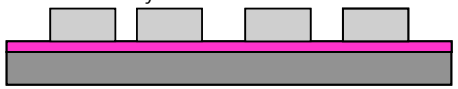
- use of new polymers / laminates
  - ➢ thin layers (10 µm) for high density
  - ➢ high breakthrough (>40 kV/mm) for power
- improved resolution for interconnects
  10 µm ➔ 5 µm ➔ 2 µm
- processes to reduce warpage

FO-PLP Process Flow Options => identical for FO WLP but much larger sie!

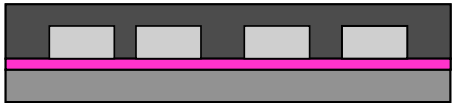
Mold first

Apply thermal release tape on carrier

Die assembly on carrier

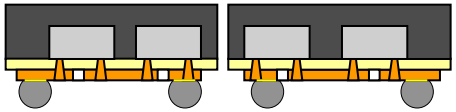


Wafer/panel overmolding



Carrier release

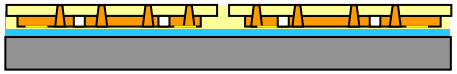
RDL (e.g. thin film, PCB based, …), balling, singulation



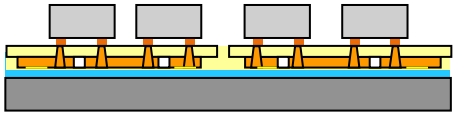
RDL first

Apply release layer on carrier

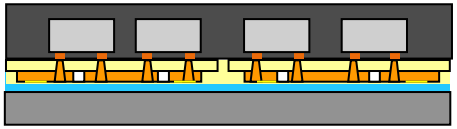
RDL (e.g. thin film, PCB based, …)



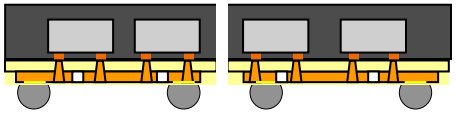
Die assembly on carrier

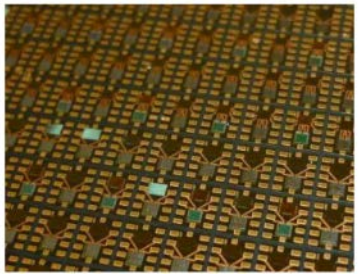


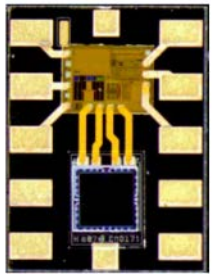
Wafer/panel overmolding



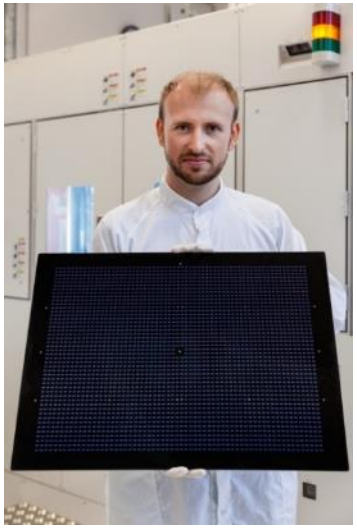
Carrier release, balling, singulation







Pressure Sensor-ASIC Package



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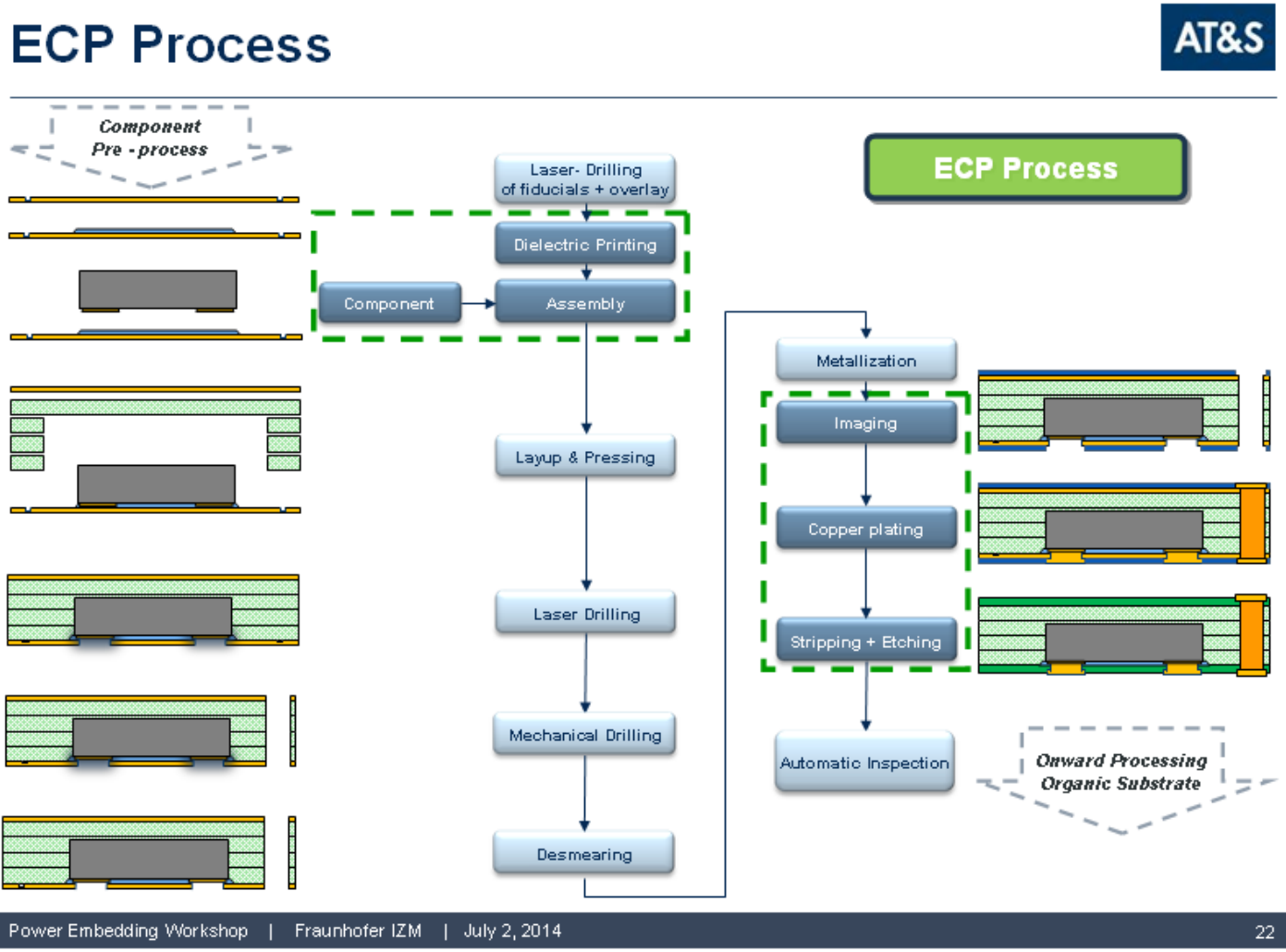
Embedded Component Panel Level Packaging (EC-PLP)



courtesy AT&S

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EC-PLP: Active and Passive Components

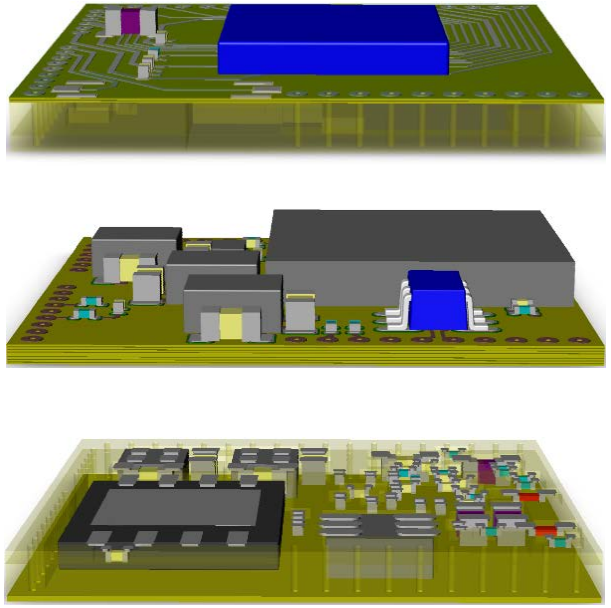
Bare Die and Packaged Components can be used

Electronic and Thermal Design

Reliability Co-Design

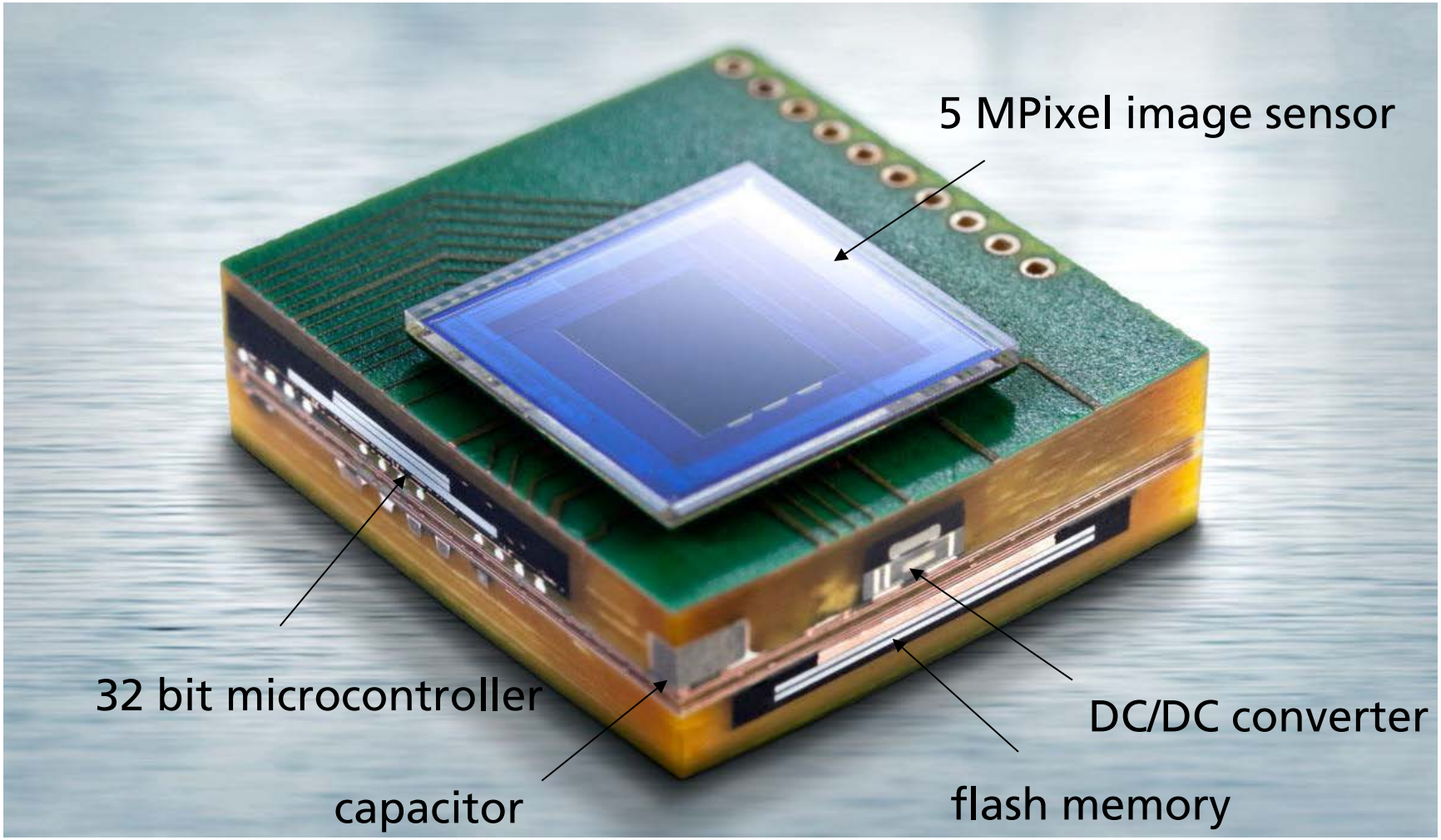
Very complex systems can be realized in EC-PLP technology

Embedding (Modular Micro Camera)



(13 active components from 8 different manufacturers)

MoMiCa – **Mo**dular **Mi**cro **Ca**mera



Modular camera with integrated 32 bit image processor and memory

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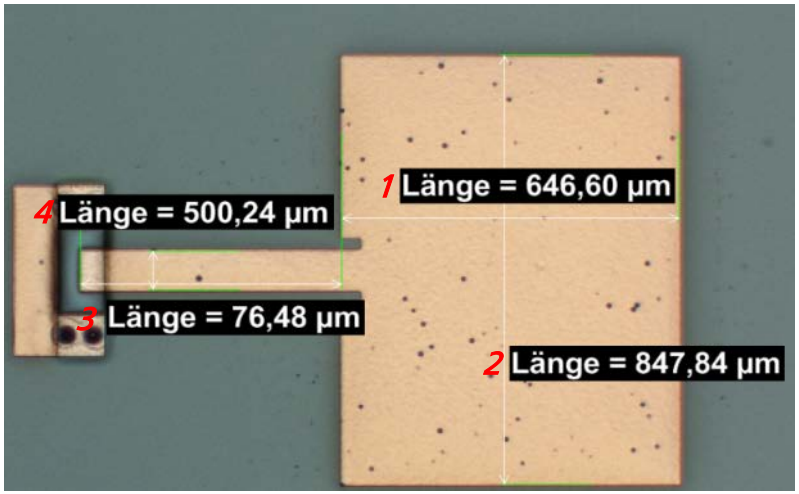
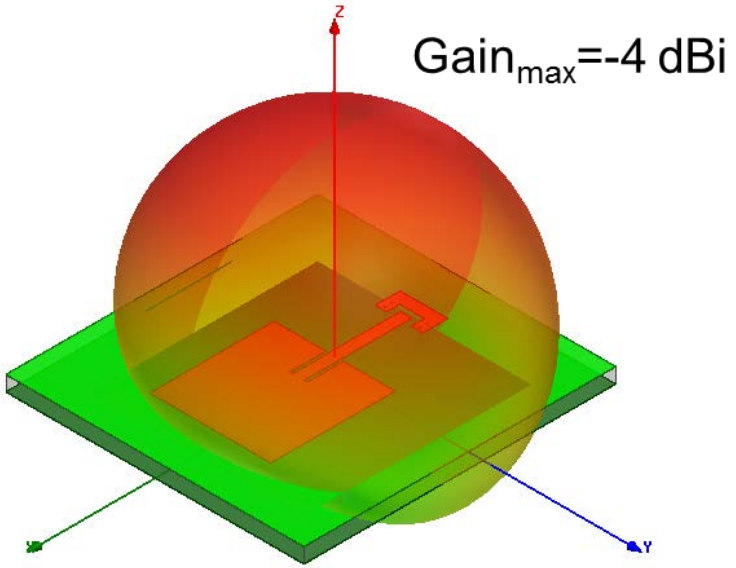
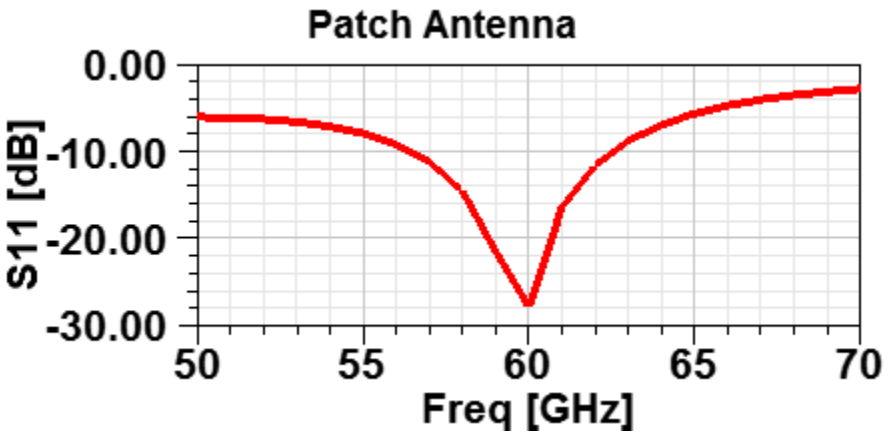
Antenna

Patch Antenna on medium resitivity silicon / Wafer Level Processing







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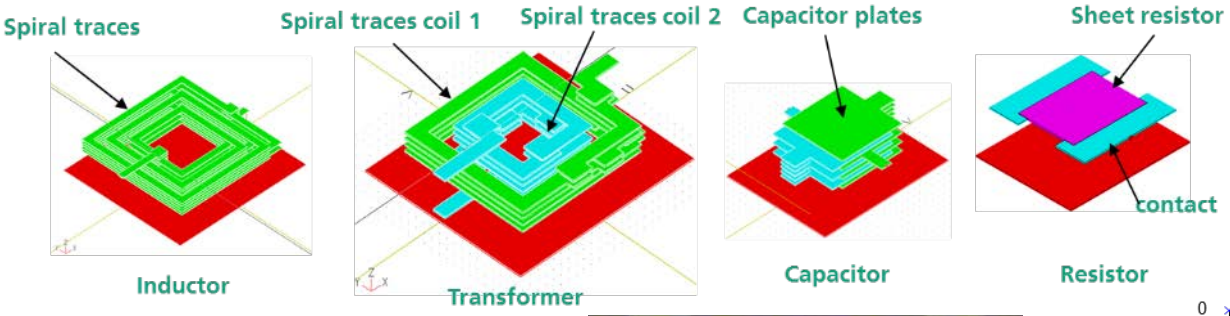
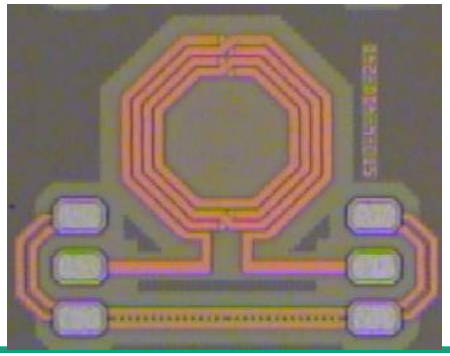
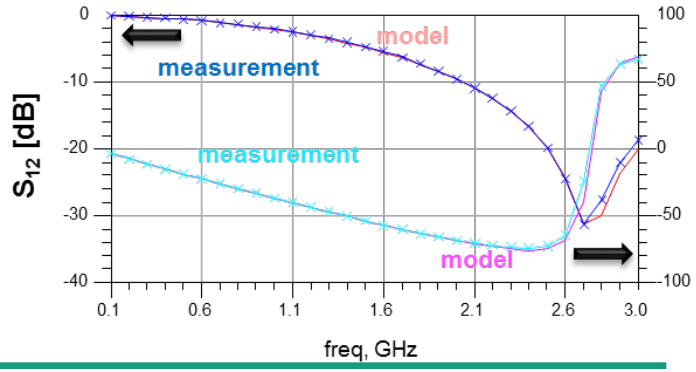
Antennas

Antennas on FOWLP SiP Packages

- Make components from substrate metal layers and dielectrics
- Electrical characteristics of embedded passives are strongly dependent on parasitic elements
- Parameterized RF models are needed to reduce design cycle







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Synopsis and Outlook I

IoT, especially Healt IoT has from an IT point of view still a lot of challenges to be adressed evolutionary

Hardware concepts become ready to fulfil the needs for Health IoT with respect to modularity, ubiquity, cost and reliability aspects

Co-Evolution of IC and Package with consideration of IoT aspects in mind right from the beginning set the path for our next generation digital world

Don´t expect monolithic silicon to fix IoT needs

Expect large area packaging to do the job ☺

Synopsis and Outlook II

IoT, especially Healt IoT has the potential to revolutionize the medicine, the hospitals and the kind of relationship between physician and patient as well as nurse and patient.

Better knowledge, eliminating time-consuming routine, prevention of waste, increasing the efficiency of processes (after analyzation)

But the technology should not be used to speed up the processes for the personal. We should use it to have more time for the interpersonal relationships.

Healthfulness is a holistic approach and the smart little electronic helpers could be a contribution but not more.

ELECTRONICS GOES GREEN 2016+

7-9 September 2016 · Berlin, Germany

Program Overview

1st day	Technical Tours, e.g. guided IFA-Tour, Get Together
2nd day	Opening, Keynotes, Sessions, Evening Reception
3rd day	Speed Networking, Sessions, Provoquium, Workshops
4th day	Sessions, Panel Discussion, Closing Session

Location Dahlem Cube / Seminaris CampusHotel, Berlin

Chairman Prof. Dr. Klaus-Dieter Lang

Schedule Call for Contributions (Deadline 15th Feb 2016)

Website www. electronicsgoesgreen.org

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